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The Welsh Engineers' and Founders' Association
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Wartime Building Supplies

Some time ago the Ministry of Works and Buildings, through its Sub-Committee on Building Supplies, drew up a schedule of the principal items required in the great bulk of the wartime building programme. Its widespread use by Government Departments and by manufacturers, merchants and contractors has led to a widening of its scope, and the original privately-circulated edition has been replaced by one obtainable from H.M. Stationery Office, York House, Kingsway, London, W.C.2, at a post-free cost of 1s. 1d.

The first section covers the requirements of Government Departments for plumbers' brass-foundry, and the weights given are based on hot pressings "which will be admitted as alternatives to castings, providing they are certified as not being made of extruded or rolled rod." There is a general classification throughout the schedule having reference as to whether the components are for use in "A" (permanent), "B" (semi-permanent) or "C" (temporary) structures. The general system used throughout the schedule has been to illustrate the component, give it a number, print an abbreviated specification for "A" with, where necessary, modifications for "B" and "C." Finally, a column carrying the heading "Minimum Ex-stock" is apparently the one for carrying the more commercial type of information.

The next section is labelled "Builders' Ironmongery," and it carries the note "Generally iron castings, but stamped steel will be admitted." A glance at the first page, which covers a rim, mortice and padlock, makes the note quoted look strange, but later on there are a number of articles to which it is strictly applicable—hinges and brackets are a typical example. There is a strong tendency to replace iron and brass articles by plastics. Much of interest for foundry owners is found in the next section, "Sanitary Appliances," for here and there are jobs previously made in other materials which are now scheduled as cast iron. Under the heading of cast-iron pipes and gutters there is a significant note reading: "Asbestos cement to be used in preference to cast iron wherever possible." It is an interesting commentary that the Ministry have managed to standardise a quantity of "fitted goods" entering the sphere of the light-castings industry, and more is promised for "a separate schedule of cooking appliances is in course of preparation and will be published through H.M. Stationery Office." The tendency we had perceived throughout the schedule in connection with the replacement of metals by plastics is well confirmed in the two appendices, the first of which gives recommendations with regard to heating and hot-water installations, and the second to electrical installations.

It will be realised that the object of the schedule is the conservation of many types of raw material for vital war purposes. The schedule is issued for the use of all technical officers of Government contracting departments and their agencies, local authorities and independent architects and engineers, as well as building contractors, builders' merchants and manufacturers of building supplies. Unless there be a definite reason to the contrary, such as special process requirements, the schedule is accepted and will be followed by all the departments—the Admiralty, Air Ministry, the Ministry of Aircraft Production, the Ministry of Health, the Ministry of Supply, the War Office, and the Ministry of Works and Buildings—which have participated in its preparation.

It should be noted that suitable alternatives from merchants' and manufacturers' existing stocks will be accepted, but manufacturers are invited in their own and the national interest to cease production of articles of a character not listed in this schedule, except where required for export.

From time to time this schedule will be revised, based on experience and the exigency of the period, and in order that major improvements may be effected constructive criticism is welcomed. The issue of any revisions will be reported in our columns. Finally, it should be stressed that the publication of this schedule is not an attempt to change normal practice or to standardise specifications, but rather to indicate how normal specifications may be modified to conserve the country's resources.

Heat-Resisting Castings of the Medium-Nickel Type

The past year has seen little change in the manufacture in the U.S.A. of heat-resisting alloy castings of more or less standardised types of analysis—medium nickel NC-4, or the 35 per cent. nickel, 15 per cent. chromium type, and the chromium-nickel CN-30 of 28 per cent. chromium, 12 per cent. nickel—MR. HARRISON I. DIXON states in a recent issue of "Metal Progress." Largely due to the U.S. rearmament programme, as well as increased production of metal parts for industry, each type has had an extensive growth in tonnage.

Instancing the service stresses and higher temperatures to which heat-resisting castings to-day are subjected, the author mentions that continuous and batch-type gas carburisers require trays and fixtures to carry heavy loads of work from room temperature fairly rapidly to 925 deg. C. under reducing conditions, followed by complete immersion of fixture, tray and work in an oil or water bath; the cycle is then completed by a tempering furnace operation, at 480 to 700 deg. C., and tray and fixtures are reloaded.

While the quenching operation produces little change in the microstructure of the austenitic alloys, the continual exposure to oxidising or reducing conditions, or both in turn, produces incalculable stresses in castings, sometimes resulting in failure from premature cracking. The use of various types of alloy additions, such as titanium, vanadium, niobium, or nitrogen-treated ferro-chrome, has reduced but not eliminated these troubles. More attention to the quality of raw materials, condition of mould and core sand and X-ray inspection is producing castings with fewer internal as well as external defects, and a resultant longer life.

Composite Carburising Boxes

The 29:9 chromium-nickel type of alloy casting, 0.20 to 0.30 per cent. carbon, has shown good corrosion resistance in the as-cast condition, without the use of a stabiliser such as titanium, as compared to the low-carbon 18:8 type in similar applications. Fabricated alloy sheet and cast "combination" carburising boxes have been improved by introducing a "tongue and groove" type of flexible joint for top and corner pieces, thus allowing a free movement of the side wall and resulting in less cracking and deformation. Castings of high-chromium iron alloys with minor nickel and low carbon (28 per cent. Cr, 1 per cent. Ni max.) are now operating as container and electrode at 1,260 deg. C. in electrically-heated salt baths for hardening high-speed steel. Casting life in such installations, where temperature is not too intermittent, now approximates six months.

Physical properties of the 24 per cent. Cr, 12 per cent. Ni and the 35 per cent. Ni, 15 per cent. Cr types, as shown by the Alloy Casting Research Institute, indicate higher ductility for the 35:15 alloy, after prolonged high-temperature exposures, with little loss of mechanical strength. This is of special importance to furnace castings (except where sulphur is present, which requires the use of 24:12).

Notes from the Branches

Lincoln Section.—There was a very well-attended meeting of the Lincoln Section of the Institute of British Foundrymen at the Technical College on November 30. Further "Problems in the Foundry in Wartime" were discussed. The proceedings were informal throughout, and terminated with tea. The next meeting of the Section is in mid-January.

America's Copper Policy

BY "ONLOOKER."

That a country so much wedded to protection of the home market by means of tariffs on imported goods as the United States should even contemplate the raising of the 4-cent duty on foreign copper is perhaps yet another indication that we live in a world which may well see radically altered lives and conditions of trading after the war. It is true that free entry is envisaged only for a specific quantity and that the importation will be undertaken by the Government in order to cope with what appears to be a temporary shortage.

To be strictly accurate, it would perhaps be difficult to make out a case for a real scarcity of supplies in America, even though the October figures did reveal a fall in the stocks of refined copper; the matter is more one of a desire on the part of the authorities to build up a reserve in connection with the munitions programme, which is likely to absorb very large quantities of copper in the coming months. Ten thousand tons has been mentioned as the possible extent of this projected transatlantic nest egg, but, judging from our experience of wartime demand in this country, that would appear to be a modest estimate, although the fact of America's vast natural resources in copper must not be overlooked. Only recently, however, it has been realised that there is quite a gap between copper in the mine and copper smelted, refined and cast into those shapes and sizes required by the various fabricators of non-ferrous products.

Tax Recovery from Exported Semis

As far as the copper situation in the United States is concerned, the wheel has turned full circle since the middle period of this year, when the collapse of Britain's Allies in Europe left South America with virtually no outlet for her mine production. Japan, it is true, was left as a prospective buyer, but the moral embargo was extended to include that country, and the properties in Chile and Peru found themselves in a difficult position. Prices began to fall and there was head-shaking in New York when the export quotation went below 10 cents; the outlook was certainly gloomy from the producers' point of view. What action was taken behind the scenes is a matter for conjecture, but, at any rate, values steadied and in due course it became known that foreign copper was being shipped to bonded warehouses in the United States, where, of course, it was able to lie for a long period without incurring a charge for import duty. An even better scheme was then evolved, for it was found possible to employ this copper in the manufacture of semis intended for export, the duty being recovered as a drawback when shipment took place.

Those who feel that already, as a result of the realisation of a common cause, relations between Britain and the United States have been improved will doubtless be tempted to read into a relaxation of the 4-cent duty, even though this is only temporary, a crack in the fabric of strict commercial isolationist policy. The British Empire is an enormous producer of copper, but Britain has held in abeyance now for some years the operation of the 2d. per lb. duty which was agreed at the Ottawa conference, and neither Canada nor Rhodesia has had cause to complain that it was squeezed out of the home market. The tariff policy adopted by the United States drove the Canadian producers to seek an outlet in Britain, while South American brands also began to come to these shores and to France and Germany; but in the present situation the tariff barrier is proving something of an embarrassment to American fabricators.

Random Shots

A Select Committee has recently decided that street lighting standards shall be standardised. "Marksman" imagines that a commodity with a name like a standard would be already standardised. Or does the committee merely mean that the man in the street shall no longer call them gaslamps in the old familiar way, but should universally adopt the more dignified name?

* * *

There seems to have been much discussion as to what tolerance shall be allowed in the erection of these gaslamps—sorry! street lighting standards. The answer is, simply enough, that they must appear straight to the eye! But the question is, of course, whose eye?—and when?—for it frequently happens that what looks straight to the eye in the cold light of morning looks anything but straight when returning from a jollification. . . .

* * *

Any committee has the right to assume that there are no such things as jollifications at a time like this, but peace *will* break out one fine day, believe it or not, and then another Armistice night may see the street-lighting standards draped with over-exuberant revellers, who, by the way, will not care whether they are straight or not.

* * *

"Can you bring me just a pound or two of treacle from the foundry for Christmas?" implored a harassed wife the other day.

"No, I can't," came the brusque reply; "and I can't bring you any Glaxo, either!"

* * *

With everyone "working through" at Christmas this year, the popular gag amongst the comedians will no longer be "'Twas Christmas Day in the workhouse," but, more appropriately, will begin, "'Twas Christmas Day in the workshop." This new version is hardly likely to produce the usual titter.

* * *

That Londoners have nerves of steel has been well proved during recent weeks, and neither have dwellers in the suburbs been found wanting. This is evident when one sees how many of the semi-detached villas still cling to the names chosen in happier days—such names as "Le Touquet" and "Le Havre." Unflinchingly the occupants daily hear that the R.A.F. have been bombing them, scoring direct hits with unfailing regularity.

* * *

With the object of stimulating the production of home-grown peeled pitprops, the Minister of Supply has decided to provide for the cost of peeling by making additions to the maximum prices. With such an incentive, everyone will be deciding to rear them on the back patch amongst the cabbages and sprouts. The local seedshop will be inundated with orders, and Mr. Middleton will be asked to broadcast a special talk on the sowing and growing of the (peeled) pitprop.

* * *

Triumph of Science.

A recent hockey match result: Nat. Physical Lab., 3; An R.A.F. XI, 2.

* * *

"They do say that there were a dozen bombs dropped round our way last night," said Mrs. Malaprop, "but I don't believe it. There weren't as many as that, not by a long stalk."

"MARKSMAN."

Gating and Feeding of High-Duty Alloys

YORKSHIRE DISCUSSION OF AMERICAN EXCHANGE PAPER

The Exchange Paper submitted by the American Foundrymen's Association to the Institute of British Foundrymen for the contemplated 1940 Conference—"Development of Some Gating and Feeding Methods for High-Duty Alloys," by Mr. A. E. Cartwright and Mr. C. C. Brisbois—was discussed by members of the West Riding of Yorkshire Branch of the Institute at their November meeting, Mr. H. A. MacColl, B.Sc., of Walsall, presiding. The Paper was published in THE FOUNDRY TRADE JOURNAL on June 13 last, pp. 443-8.

American Co-operation

MR. VINCENT DELPORT (Past-President of the International Committee of Foundry Technical Associations) came from London to open the discussion. In his introductory remarks Mr. Delport congratulated the Branch on having carried through a full programme last session and on its determination to do so again in the present winter, in spite of the difficult conditions affecting foundrymen in wartime.

Mr. Delport assumed he had been invited to the West Riding because of his connection with the American Foundrymen's Association. It was perhaps more than a happy coincidence that the joint authors of the Paper were Canadians. Although he had not been specifically commissioned by the A.F.A. to represent them officially, he was quite certain that they would wish him to take advantage of the opportunity to extend to the members their most cordial greetings, to express sincere wishes for the continued success of the Institute despite the difficult conditions under which it was labouring, and, above all, to assure members of their heartfelt sympathy for the ordeal through which all were passing to a greater or less degree, and their admiration for the manner in which the British were facing the trial.

It might sometimes be difficult for people here to understand the official attitude of the United States in regard to the war, but it would be realised that such a large country had many problems of great magnitude to solve, and that the authorities had to take account of many cross-currents of opinion. He assured his audience that all true Americans were sympathetic in the extreme. They had shown their feelings in the many ways in which private individuals and collective groups had contributed to the Red Cross, to the proposed evacuation of British children, and in many other directions. They were showing it now by the very valuable material help that the Administration was sponsoring, with the full concurrence of the large majority of the American people, and he could personally vouch for it by the many letters he received, which all expressed kind thoughts for the British people and a strong hope for a British victory. He felt he should express these thoughts because he was convinced that real and lasting peace would not return to this world without a common and deep understanding between the American and British people.

Industrial Collaboration

Turning to the Paper under consideration, Mr. Delport said he did not propose to discuss its technical aspects, but he would like to take it as a text for a few thoughts of general interest to the foundry industry, and he would attempt briefly to sum up the Paper in order to start an exchange of views by the West Riding members. In their introductory paragraphs, the authors had brought to light a certain aspect of the necessary collaboration between metallurgist and foundrymen. Among the activities of the metallurgist was the constant quest for better castings, not only by using special alloys that gave better resistance to wear, heat and abrasion, but also improved castings made from ordinary iron—more homogeneous castings and fewer wasters; in general, more regular and more economical production.

The authors were quite aware of the fact that progress along the lines indicated brought about added difficulties in foundry practice and technique. The operation of a foundry equipped for modern production required a considerable amount of technical knowledge, skill and organisation, and there was going to be more direct contact between the metallurgist in his laboratory and the foundry manager and moulders and melters; and that was all for the good. In connection with this question of collaboration between the research worker and the practician, Mr. Delport quoted a passage from the address which the late Lord Rutherford, that great New Zealander, delivered when he became President of the British Association in 1923: "If the fundamental researches of the workers in pure science supply the foundations on which the applications are surely built, the successful practical application in turn quickens and extends the interest of the investigator in the fundamental problem, while the development of new methods and appliances required for technical purposes often provides the investigator with the means of attacking still more difficult questions."

The results described in the Paper from America were due to such collaboration. The time had gone when the so-called "practical man" looked upon the metallurgist as a man solely concerned with science and theory, and far removed from the problems that had to be confronted on the cupola platform or at the moulding station. It was now recognised that without the patient research work of the metallurgist the foundry industry would not have reached the position of prestige that it had now attained, nor would the iron foundry be able successfully to compete against other forms of fabrication in order to satisfy modern engineering requirements. On the other hand it was evident that all the work done by metallurgists would be of no avail if foundrymen had not, themselves, improved their methods and made the necessary efforts to keep informed of continuous developments. In this connection mention should be made of the facilities afforded to-day for the distribution of specialised foundry knowledge, and of the opportunities given for the interchange of knowledge by such organisations as the Institute.

Improved Feeding Methods

The methods of feeding described were, no doubt, not unfamiliar to most members, but perhaps they were not used over here to a very great extent. The authors had made a specialised study of the subject and had successfully translated the results of their experiments into practice. They now published the results so that all might benefit from them. This was eminently a practical Paper, while being the result of much research work. There were probably many points that members would wish to discuss. They might find, for instance, that head feeding was not the best method in every case, because of the different nature of moulding sands—or it was possible that some members were satisfied with the method in use. The authors themselves stated that direct feeding-head pouring was not uniformly applicable to all designs. At all events, he had no doubt that the authors would gladly answer all questions, even though their replies would have to be in writing, and that members would benefit from their own mutual exchange of remarks.

The BRANCH-PRESIDENT (Mr. H. A. MacColl) thanked Mr. Delport for his opening remarks. British industry was greatly dependent, he said, on American co-operation at present, and anything that fostered friendship between the two countries was to be encouraged. An impression on reading the Paper was that perhaps the methods advocated were to a considerable extent what was normal practice in steel founding, in which direct feeding gave very satisfactory results. It did, however, make for substantially increased cost, and that was a factor which must be taken into consideration.

Top Feeding No Panacea

MR. F. K. NEATH, B.Sc., felt the Paper was a development of a long-standing "feud" between the advocates of top-pouring and those of low-level practice. There was much to be said in favour of top pouring, which gave metal set at the bottom almost before one had finished pouring. The feeders were filled with fresh, hot metal and the body itself had already done some feeding to the lower portions. The whole principle was a logical development of much that had been argued about in the Institute's meetings and performed in this country.

In the end the authors quite clearly and frankly admitted they did not advocate top pouring for every casting. They admitted that it would not always answer, and they actually showed, in Fig. 14, a "waster" as a result of the wrong method of moulding a Monel centrifuge casting. Moreover, Fig. 16 was an excellent piece of work showing the way they overcame the trouble by the use of denseners and side pouring. They had had the pluck to show their failures as well as their successes, and members should congratulate them. There were some metals mentioned in this Paper which admittedly were not used much in this country, but the general principles were the same, as all metals required feeding.

MR. A. S. WORCESTER said that, whilst the Paper related particularly to high-duty alloys, all its principles were applicable to producing castings from ordinary common grey iron, and it was an excellent and valuable contribution. Members' minds were carried back to the time of the Papers by Ronceray on top running or strainer running to deflect thought into the right direction. The West Yorkshire Branch, especially Mr. S. Carter (Past-President) had done more work in this direction than he had encountered in other districts, with much success. It was a fact that if a casting was cast up with a fairly long, straight runner, there was, as a consequence, a certain amount of turbulence in the metal, and it must impinge on the sand, especially if it was not blacked. Thus there was much to be said for this method of strainer running.

Wide Application

MR. S. CARTER said the departure from ordinary practice to meet the calls of high-duty irons was obviously necessitated by the difficulties encountered in liquid shrinkage in metals of a short freezing range. Whilst the practice illustrated by the Paper confined itself to these high-duty alloys, he considered that the methods employed had a wide field of application in the sphere of ordinary grey iron, although, as pointed out by the authors, application must necessarily be limited to dry-sand moulding on account of the fragility of the small neck end of the bottle-shaped riser.

The absence of dimensions on the illustrations did not assist in the proper appreciation of the value of the methods employed, and it would

be very interesting to know, amongst other things, the thickness of the strainer cores used for passing the 2 tons of metal into the bushing illustrated in Fig. 8. In a long experience of strainer cores and their application, he would not care to employ a core 1½ in. thick, in oil sand, for the particular casting in question, owing to the tendency for fusion when the bonding agency disintegrated. This casting commended itself to the speaker as a fine illustration of the achievements claimed by the authors for the methods employed, and contrasted very favourably with English practice, which would have used an extension of the casting as a feeder head to be cut off in machining and returned to the foundry—all at considerable expense.

Sphere of Application

The application of this system for large compact masses of iron appeared to be a very fruitful proposition, and could be well recommended for the bosses of large gear blanks, flywheels, couplings and the like. The nature of the metal used in making the valve body in Fig. 9 was not stated, but the necessity for using this method of running and feeding was not apparent. Such a casting, emerging from a mould in England, would be considered a freak, and he believed he was right in stating that 90 per cent. of British founders would attempt to produce these castings satisfactorily by means of denseners in preference to the obviously expensive and elaborate heads employed by the authors in this case.

The authors mentioned the feeding rod in describing methods used for compensating liquid shrinkage, and a personal opinion was that any method which could eliminate this most inconsistent and unsatisfactory process from a foundry merited recommendation. It was almost true to say that as many castings had been spoiled by the rod as had been saved, and in their departure from hidebound foundry practice the authors were to be congratulated on their calculated and scientific approach to one of founding's worst difficulties. Mr. Carter amplified his observations by some blackboard illustrations of his own work, as mentioned by Mr. Worcester.

Gear Blanks

MR. F. OLDERSHAW, referring to a gear blank sketch which Mr. Carter suggested as the type of job that would yield a satisfactory result by the top running method, said he would be inclined to run that particular job in the bottom, with a small runner and two risers at the top. There was a great deal in the way of handling the feeding, and much depended on who carried out the work, and the care or otherwise put into it. The object was to keep the neck of the riser open and let hot metal sink into the casting. With a hard iron one could not cast with what was known as "cold" metal. There must be enough fluidity after the metal had left the mould to allow it to feed back. Answering a remark by the President, Mr. Oldershaw said he had tried steam feeding, but he regarded it as more trouble than it was worth.

MR. CARTER, giving several other blackboard illustrations of jobs he had tackled much on the lines suggested in the American Paper, remarked that one of the points that did not seem to have been raised was that of running through an oil-sand core.

MR. NEATH said a point to remember, also, was that the metals used in this Paper were not the ordinary common irons.

A MEMBER asked whether, when casting a small job and skimming the metal, a strainer core was advisable.

MR. CARTER said that such was the case, as one could ensure the elimination of slag and dirt.

MR. NEATH endorsed Mr. Carter's plea for a strainer core as a means of ensuring the greatest possible cleanliness of the metal.

MR. S. W. WISE suggested that the strainer core would retard the flow of metal. He drew on the blackboard a strainer core as operated by himself in regular practice for a 3-cwt. job, using sea sand. He agreed, in answer to questions, that if any difficulty were experienced he would turn from sea sand to ordinary foundry sand. Mr. Wise's illustration showed two circles of holes, the places for passing the metal being ⅛ in. diameter less at each stage.

Use of Strainer Core

MR. G. ILLINGWORTH stated that this was the first occasion he had seen the metal introduced on to the top of the strainer core in the way illustrated by Mr. Wise. The authors of the Paper gave the size of the head to the moulder and the core was made to fit into the top of the riser. (Mr. Illingworth illustrated his point on the blackboard.) The strainer core was level with the top of the moulding box and they introduced a pouring box. The pouring box being rammed up, the authors introduced a "pinch" effect, but there was no actual direct pressure on top of the strainer core.

MR. WISE said that about 1912 he used a strainer runner which he thought was a wonderful discovery such as nobody had made before—until he saw an article in the technical Press by a man who had made a strainer runner thirty years previously!

The BRANCH-PRESIDENT suggested that the meeting might take one or other of the examples in the Paper and say whether they agreed or, if not, what they would do themselves. Let them take, for instance, the coil-wire annealing pot illustrated in Fig. 5 and showing the gating arrangements. The authors had used four large heads on the ribs with a strainer core on those. What alternative methods had members to offer if they did not agree with that? Successful castings, presumably, were being made by their own methods. What advantage was there in taking up this other way with its slight complications? If members were to change methods they must obviously have some expectation of definite advantage. Did this method offer such an advantage over their existing practice as to justify the change?

Answering Mr. Carter's comment that discussion was handicapped by the absence of dimensions, Mr. MacColl said he would suppose this particular item was possibly five to six feet high, perhaps 30 in. dia. and 1 in. thick.

MR. CARTER said that in his opinion, for that particular job, the authors' method would have no great advantage over normal district practice.

MR. NEATH said Diesel-engine founders in the North-East used a header such as was shown in Fig. 5, but from their experience they would bottom-pour it. They would make it a continuous header, and he did not think there was much difference between the authors' practice and that of the Diesel-engine makers in this country.

MR. ILLINGWORTH felt it was a little unfortunate that the Paper did not give analyses of the irons used, thereby leaving discussion without any true conception of shrinkage.

MR. DELPORT, referring to the desire for dimensions and analyses, felt it would be a good thing to ask these questions of the authors themselves and await the answers in writing. The members would appreciate, of course, that this might take some little time. As regarded the question as to advantages of the system, an outline of advantages was given in the Paper under the heading "Advantages Obtainable by Direct Riser Pouring." The advantages, as suggested by the authors, were set out in four definite points there. The point was, Mr. Delport would suppose, whether members of

(*Continued in next column.*)

Grids or Plates for Turn-over Boxes?

BY W. GUDGEON.

In foundries where it is the practice to ram jobs up in turn-over boxes, the use of grids bolted to the bottom part appears to be the generally accepted practice. Yet considerable risk attends their employment in one or two ways, and in the moulding of certain jobs disaster may be encountered. In the space of twelve months, the writer has witnessed the loss of four jobs, with rather unsightly swells on another three castings. In every case the use of a plate instead of a grid would have prevented the molten metal from finding its way through the bottom of the mould, the reason for this being a weak place in one or more of the grid spaces. With a weighty job, where there are only three or four inches of sand under the grid, either of the mishaps is liable to happen. A glance at the sketches (Figs. 1 and 2) will show why, with the employment of a plate, there is no danger of a run-out.

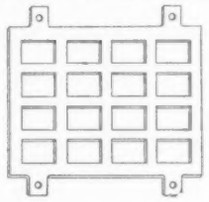

FIG. 1.—GRID FOR TURN-OVER BOX.

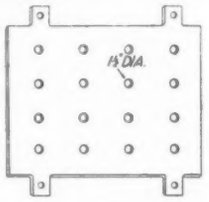

FIG. 2.—PLATE FOR SAME BOX.

The prevailing objection against the use of plates is the notion that they prevent the easy escape of air from the mould, thereby causing scabs on the bottom of the casting, whereas the open spaces of the grid provide an excellent outlet. This is a mistaken belief, disproved by experience. Holes about 1½ in. dia., cast in the plate and spaced 18 in. apart, will allow the air to escape quickly, another sure method being to push a ¼-in. vent wire between the plate and box-part, this operation to be carried out before the pattern is withdrawn.

The use of a grid necessitates hoisting the box up at least 2 ft. above the floor after it is turned over, this to ensure there are no hollow places underneath it.

What often happens is that the sand in the open spaces of the grid is jerked out as the box turns over, and much time is used up by the moulder until he is satisfied that the displaced sand has been restored, although the risk of a run-out from the base of the mould is not entirely eliminated. With the use of a plate these risks are non-existent.

(*Continued from previous column.*)

the Institute agreed with the advantages as suggested by the authors, or had other ideas of their own against them.

MR. WORCESTER, proposing a vote of thanks to Mr. Delport for his visit and opening the discussion, paid tribute to him for travelling from London to speak on a Paper which was not actually his own work.

MR. OLDERSHAW seconded, and MR. WISE warmly supported the proposal.

MR. DELPORT, replying, said he had greatly enjoyed his visit. They might not, during the evening, have kept discussion to strict arguments on all the points in the Paper, but the value of a Paper, after all, was very largely in the opportunities it created for opening up other aspects on the kindred subjects. He would, nevertheless, welcome any written comments or questions which members may individually care to send for the attention of the authors.

Some Points in Casting Production*

By E. LONGDEN, A.M.I.Mech.E.

As a preliminary to a detailed description of the production of important iron castings, made in certain respects in an unorthodox way, it will be helpful to restate and refer briefly to the constituents of cast iron. The references will be without the complications and complexities that it is possible to introduce to the modern understanding of the heterogeneous metal, cast iron. It is because of the peculiar properties inherent in cast iron that the method applied to the making of a large casting to be outlined is possible.

CAST IRON

Cast iron is normally composed of iron, modified by the presence of varying percentages of other elements, usually referred to as impurities, namely, carbon, silicon, phosphorus, manganese and sulphur. The influences exerted by the impurities are much greater than would be superficially expected by the percentages disclosed by analysis. The elements named form, with iron, compounds, occupying a large volume of the mass of metal. An iron with, say, carbon 3.3, silicon 2.0, phosphorus 0.8, manganese 0.8 and sulphur 0.08 per cent., contains approximately 7 per cent. of impurities, but the compounds formed therefrom occupy 34 to 38 per cent. of the volume of the metal.

Cast iron is essentially an iron-carbon alloy. The properties of the normal range of cast irons are very largely determined by the amount and condition of the carbon. The remainder of the elements usually present in the metal exert their respective influences on the amount and condition of the carbon much more than they directly influence the metal. The condition of the carbon and the crystallisation of the metal is also very considerably influenced by the rate at which the metal solidifies and subsequently cools to below about 710 deg. C.

In addition to the elements normally present in cast iron, other additions may be made to the metal to influence, mainly, the carbon, namely: Nickel, copper, chromium, titanium, aluminium, vanadium, molybdenum and compounds such as calcium silicide. But alloying additions, however, will not have any bearing on the points discussed in these notes. Carbon is the element which concerns the special reference to the production of a large boring-bar casting. In considering carbon, however, it is necessary to sketch, briefly, the effects on the carbon of other elements normally present in cast iron.

Carbon

Carbon exists in cast iron in two main conditions, one condition being as combined carbon (carbide) and the other as graphite. The carbides formed are iron carbide and manganese carbide, and, in alloy irons containing chromium, a chromium carbide. Carbide may be so dispersed in the metal as to form in regular stratified association with iron (ferrite) a so-termed pearlite structure. If not so allied, it is termed free cementite (combined carbon). Increasing hardness, shrinkage and brittleness are associated with increasing proportions of carbide compounds. Graphite produced from the decomposition of the carbides, resulting from the presence in the metal of graphitising elements and the cooling rate, may be found in many states. Graphite is variously described as flaky (fine, medium and long), nodular, curly, temper and sooty.

In normal grey cast irons, the total carbon contents range from 3.10 to 4.00. The combined carbon will vary in amounts up to 0.89 or 0.9, the remainder of the carbon being present as graphite.

Certain of the elements in cast iron induce a precipitation of graphite from a carbide solution. Other elements favour, primarily, the retention of the carbon as a solid solution (carbide). The amount of graphite precipitated affects the specific gravity of the metal. A soft graphite iron may have a density of 6.9, against 7.6 for a very close-grained iron.

Kish graphite is free carbon which rises to the surface of molten cast iron as the temperature falls to the freezing point. Kish will occur in a supersaturated carbon alloy with high percentages of silicon. This form of graphite is due to the inability of the metal to hold the carbon in solution in excess of a certain percentage, depending upon the presence and amounts of other elements, except at a very high temperature. Kish is, therefore, graphite which is precipitated before solidification of the metal. Certain classes of hematite and medium phosphoric irons with high total carbon and silicon can, at times, be noted as being of a "kishy" quality.

With most classes of cast iron, however, the present limited knowledge would indicate that when the metal is molten, the carbon is in solution with the iron, or other metallic content, forming carbides. Up to the point of solidification the metal, therefore, carries carbon, primarily as carbide which, on further cooling, persists or dissociates with the production of graphite. Decomposition of carbide is accompanied by an evolution of heat and an expansion on dissociation, the precipitated carbon taking up a larger volume than the carbon when in solution with iron. The specific gravity of carbide being about 7.6 and graphite between 1.8 to 2.2 will explain the expansive force set up by carbon precipitation. Graphite may, consequently, occupy four times the volume of carbide from which it has been formed.

Additionally, very minute voids may exist around the graphite particles, which enhance the apparent size of the graphite formations. It is considered that graphite is the ultimate stable condition of carbon. The volume change due to the dissociation of carbide will, therefore, account for the lower specific gravity of cast iron compared with steel and the reduction in liquid shrinkage. Pure carbon alloys do not expand permanently, whilst alloys containing graphite grow.

Various theories are put forward with respect to the mechanism of growth in cast iron. In the malleablising of white cast iron the amount and condition of the carbon are changed whilst the metal is solid, but at elevated temperatures. In the whiteheart or European process, much of the carbon is abstracted from the metal by gasification and oxidation of the carbon which is present in the metal as carbide. A suitable atmosphere is created by the packing medium which contains a proportion of oxide in the form of hematite ore, the temperature of the atmosphere ranging between 920 and 950 deg. C. A portion of the carbon remains, mostly, as a secondary carbide and a trace as graphite, but most of the carbon passes out of the metal. With the blackheart or American process, there is only slight decarburisation of the outer skin of the metal, the great bulk of the carbon being precipitated to form graphite. Only a trace of carbides remains. The annealing oven atmosphere for blackheart is not necessarily oxidising, a neutral packing material being employed to surround the castings in the annealing pans. The temperature of annealing is also lower by 50 deg. C. than is usually necessary for the whiteheart process.

In spite of the low percentages of silicon, the blackheart castings can be made to grow if subjected to repeated heating and cooling. The volume change in a cooling grey iron is not due to oxidation, but to the precipitation of primary and secondary graphite. Oxidation plays an important part in the decarburisation of whiteheart malleable iron, but the small growth during annealing of both whiteheart and blackheart is due to the precipitation of temper graphite.

Silicon

Silicon combines to form iron and probably manganese silicides. The element is present in cast iron from 0.5 to 15.0, but usually between 0.9 and 3.0. In the presence of the usual quantities of carbon contained in the cast-iron range of metal, silicon promotes the precipitation of graphite from carbides during the cooling of the iron. Thus, by reducing the solubility of carbon, silicon acts as a softener.

It reduces the amount of carbon dissolved by iron. The higher the silicon content, the more slowly the iron dissolves carbon Sulphur pick-up is also reduced by the presence of silicon. Silicon also lowers the freezing point of iron; the solidification range is extended and the fluidity increases with silicon contents up to about 3.5 per cent. This element decomposes all types of carbides. In normal cast iron with ordinary carbon contents, silicon favours growth in castings subject to repeated heating and cooling.

Phosphorus

Phosphorus forms, with iron, phosphides, the most common having a molecular formation of Fe_3P, although other combinations are known to exist. Phosphorus dissolves very readily in pure iron up to 1.7 per cent., but its solubility diminishes with increasing percentages of other elements, notably carbon. Carbon reduces the solubility of the phosphide compounds by requiring its own quota of iron. It is known that the presence of phosphorus or carbon will decrease the solubility of either element. If carbon be added to a saturated solid solution of phosphorus in iron, phosphide will be thrown out of solution, and if phosphorus be added to a saturated solution of carbon in iron, carbide will be thrown out of solution. It is calculated that five parts of phosphorus will lower carbon content by one part. Phosphorus progressively lowers the melting point of iron, increases fluidity, reduces contraction, increases hardness and brittleness.

Manganese

Manganese is a metal, and along with iron forms double carbides—manganese carbide (Mn_3C) and, with sulphur, a manganese sulphide (MnS), in preference to iron sulphide (FeS), which preference is of considerable benefit to the quality of the metal, since a percentage of the manganese sulphide may pass out of the metal as a fluid slag at comparatively high temperatures—about 1,550 deg. C., compared with iron sulphide at less than 1,000 deg. C. Manganese possesses strong deoxidising properties when present in moderately high and low percentages, and appears to protect both carbon and silicon somewhat from oxidation in the cupola. The element possesses a greater affinity for carbon than iron for carbon, resulting in an increase of the carbon content of the metal.

Therefore, the direct effect of manganese is to increase the total carbon content of the metal and the formation of carbides. The indirect effect of the element, within a certain ratio of sulphur to manganese, will be softening. After supplying enough manganese to balance

(*Continued on page* 382.)

D

* Paper presented to the Lancashire Branch of the Institute of British Foundrymen, Mr. W. Holland presiding.

Rot-Proofing of Sandbags

A SIMPLE PROCESS

Sandbags filled with sand or soil and exposed to the weather are particularly liable to be attacked by the micro-organisms that cause rotting, and may in a few weeks become as much a danger as a measure of protection. The announcement of a remedy is therefore of the first importance, especially if the treatment is both cheap and simple. Such a method has been developed by Imperial Chemical Industries, Limited, for it consists simply of dipping the bags in two common chemicals, sodium carbonate and copper sulphate. Treatment with this mixture at the present price works out at no more than one-tenth of a penny per bag of normal size. It will, it is estimated, increase the life of sandbags in service at least eight times.

The bags must be treated before they are filled. No rot-proofing process is satisfactory when applied to bags already in place. Whether they are treated before or after being sewn up, particular care must be taken to treat the thread used for the seams, as it is often here that the rotting begins.

During the research into the rot-proofing of sandbags that I.C.I. have carried out over the past two years, samples of treated and untreated jute and cotton fabrics have been buried in garden soil for eight months. The fabric treated with the mixture remained in excellent condition. while the untreated fabric was almost completely disintegrated.

Equally good results were obtained with solutions of copper sulphate and soda used separately. It is obviously simpler to use the one-bath process, but in treating compact and tightly woven materials, or sandbags in compressed bales, it may be preferable to use successive immersions of copper sulphate and soda ash or washing soda. It is the copper which gives the resistance to rotting, and both these simple processes have been proved to give just as good results as the use of more expensive copper products.

Method of Treating

The mixture used for the rot-proofing of sandbags is technically known as a basic copper carbonate suspension. Use 4½ lbs. of soda ash or 11¼ lbs. of soda crystals in 5 galls. of water and stir this slowly into a solution of 10 lbs. of copper sulphate crystals in 30 galls. of water. Use a 50-gall. wooden vessel—not one of iron or galvanised iron. Make up the quantity to 40 galls. and add 2 ozs. of calsolene oil HS. (Calsolene oil HS is a "wetting agent." It assists the penetration of the fabric and adds very little to the cost.) Stir well. Immerse the sandbags until they are thoroughly saturated. Remove the excess liquor by wringing or in a hydroextractor. After wringing the bags should weigh twice their original weight. The bags should then be dried at a low temperature. Bags should be immersed for at least 5 min. if cold water is used, but the process can be speeded up by warming the water to 30 to 40 deg. C.

Further particulars can be obtained from Imperial Chemical Industries, Limited.

U.S. Steel Industry Expansion

More than 100,000 employees were added to the payrolls of the U.S. steel industry between August, 1939, and August, 1940, according to the American Iron and Steel Institute. During August the average number of employees at work in the industry was 560,000, compared with 549,000 in July and with 458,000 in August, 1939. The number of hours worked by wage earners averaged 36.7 per week in August, as against 36.5 in July and 36.2 in August, 1939.

Determination of Forms of Sulphur in Coal

In the course of work on storage of coal at Birmingham Coal Survey Laboratory of the Fuel Research Board, it became necessary to examine critically the determination of the forms of sulphur in coal of different size grading, and also the constancy of the amount of organic sulphur in fresh commercial grades, according to the Report* for the year to March 31, 1939, of the Director of the Board, just issued by the Department of Scientific and Industrial Research. The first object was to determine whether the gravimetric methods based on the work of Powell and Parr could be relied upon with samples such as fine screen fractions, which contain relatively high percentages of pyrites and other mineral matter. Some difficulty had been experienced with samples of this nature. The organic sulphur content of the coals was also investigated with a view to determining (*a*) whether it was constant in different consignments of the same grade from a particular colliery, and (*b*) whether it was subject to alteration by weathering or by storage.

In order to determine the reliability of gravimetric analyses of the sulphur forms, parallel tests were carried out by different operators using (*a*) the gravimetric methods of Powell and Parr and (*b*) the volumetric (titanium chloride) method. In (*a*) the pyritic sulphur is determined by precipitation after extraction, and any organic sulphur which is dissolved by the reagents is included. In (*b*) the iron of the pyrites is determined volumetrically, and the equivalent sulphur is calculated; this method is therefore free from the error mentioned above, but other possible errors, such as incomplete solution of pyrites. are common to both methods. For the purpose of the investigation a fresh sample of "pearls" was obtained and screened into eight fractions, subsequently grinding where necessary to pass through a 72-mesh B.S sieve. In order to determine the effect of fineness of grinding, portions of two fractions were ground to pass through a 240-mesh B.S. sieve, and these were included in the test. Further, in order to establish the effect of the presence of relatively high percentages of pyrites and other mineral matter, flotation tests were carried out on the "dirty" fractions. A mixture of carbon tetrachloride and benzene of specific gravity 1.40 was used for flotation, and tests carried out on the liquid after use showed that no appreciable amount of organic sulphur had been dissolved. The float and the sink portions of the fractions were tested in the investigation. All the samples involved were subjected to such analyses as are required for the calculation of mineral matter and the organic sulphur contents.

As a result of these investigations, the following conclusions were drawn:—(1) The gravimetric and volumetric methods gave concordant results with all the samples tested, showing that there had been no appreciable solution of organic sulphur during the nitric acid extraction of pyrites. (2) Grinding to pass through a 240-mesh B.S. sieve was not necessary, at least in samples containing up to 3 per cent. of pyritic sulphur. (3) The organic sulphur content of the screen fractions tested. calculated to a pure coal basis, was substantially constant. (4) The organic sulphur content (on a pure coal basis) of each commercial grade of the coal used (High Delf) from one colliery was substantially constant for different consignments, but there was a slight change from one grade to another with a tendency for increasing organic sulphur with decreasing particle size. (5) The organic sulphur content on a pure coal basis was not affected by weathering when there was no rise in temperature.

* H.M. Stationery Office, York House, Kingsway, W.C.2. (Price 3s. 6d. net.)

Porcelain-Enamelled Corrugated Iron

According to "The Iron Age," the widespread application of porcelain-enamelled iron has recently been extended to roofing and siding with the development of an interlocking corrugated sheet porcelain enamelled on both sides, combining the corrosion-resisting qualities of porcelain enamel and the strength and fire-resisting qualities of steel.

Created by Porcelain Steels, Inc., Cleveland, under the name of "Por-Ce-Lok," it provides a different and decidedly durable building material for roofing and siding. To fabricate this new product, a special cold-roll forming machine was designed by Kane & Roach, Inc., Syracuse. Taking sheets of 20 to 26 U.S. standard gauge enamelling iron, 32 in. wide and from 5 to 10 ft. long, it delivers them at the rate of 120 ft. per min. During the forming process, a 32-in. sheet loses 8 in. in width.

In laboratory tests the double-coated porcelain-enamelled sheets were subjected to 565 hrs. of fog and salt water and 16,800 hrs. exposure to the Weatherometer, ultra-violet rays and heat. At the end of this test, the equivalent of many years, there was no indication of coating failure.

With its interlocking flange, "Por-Ce-Lok" is easily assembled. The pre-punched holes are protected by porcelain enamel, while straps, clips, bolts, and sheet metal screws are supplied galvanised, sherardised, or cadmium plated. There are no exposed holes and all attachments are concealed. The material is available in royal blue, forest green, maroon and autumn brown.

Industrial Lighting Service Established

The question of industrial lighting in wartime, when factories are working longer hours than usual under artificial illumination, has so many bearings upon health and those matters usually summed up in the term "efficiency," that the formation of a National Industrial Electric Lighting Service may be regarded as an important step in the general organisation of the country's war effort. In July, 1940, the Fifth Report of the Departmental Committee appeared advocating the compulsory adoption of lighting regulations in factories. Under draft Statutory Rules and Orders there has now appeared the Factories (Standards of Lighting) Regulations, 1940, prescribing a standard of lighting for factories working more than 48 hrs. a week or in shifts.

At a meeting held at the Lighting Service Bureau, eight of the various associations interested in electric lighting were asked to nominate representatives to an Executive Committee which should deal with any matters referred to them by Government Departments concerning artificial illumination. Briefly, the whole matter of wartime factory lighting has now crystallised in the establishment of the National Industrial Electric Lighting Service, with its secretariat vested in the Lighting Service Bureau, London, and with local offices at Glasgow, Newcastle-upon-Tyne, Leeds, Manchester and Birmingham. The chairman is Sir Duncan Wilson and the secretary is Mr. W. J. Jones. Summarised, the object of the scheme is to mobilise the services of qualified lighting engineers throughout the country, in order that employers may be advised, with the minimum of delay, of the best and most economical way of complying with the new lighting regulations made by the Minister of Labour and National Service.

Further particulars may be obtained from E.L.M.A. Lighting Service Bureau, 2, Savoy Hill, London, W.C.2.

THE TIMKEN ROLLER BEARING COMPANY, Canton, Ohio, have recently placed an order for a second 60-ton capacity electric furnace. The firm possesses a 100-ton electric furnace—the largest in the world.

Prehistoric and Primitive Iron Smelting

THE CRUCIBLE PROCESSES OF THE EAST*

By E. WYNDHAM HULME, B.A.

The discovery that fine gold could be made available for working by melting in crucibles with forced draft was an invention of the 3rd Millennium B.C., the importance of which in the development of civilisation has been somewhat overlooked. The Golden Age, which it ushered in, is represented in archæology by the Bronze Age, with which it is roughly contemporary. It was an age of adventure by land and sea by bodies of men who combined trading with mineral prospecting. It was, as the poets have described it, relatively a peaceful age. The Silver Age which followed it is the age of the Hittites, *i.e.*, the silver men, the economic basis of whose Empire was the wealth of the silver mines of Cilicia. The dissolution of the Hittite Empire, *c.* 1200 B.C., marks the introduction of the Iron Age, *i.e.*, the age characterised by its use of iron on an industrial scale, which in a previous Paper the author traced to the development of iron-making in N.W. Persia.

It is interesting to note that in the Ancient East peoples reputed for their metallurgical knowledge, for example the Sumerians, Chalybians, Dactyli or Telchinians, possessed either traditions of a marine origin or are known as mariners. These traditions are indicative of folk movements, mainly from the East, passing through Persia and Asia Minor to the Aegean, Crete and Macedonia. The immigrants from the East brought with them new religions and a reputation for agricultural and metallurgical skill. Further strange claims were in some cases advanced to weather control, and possibly some inkling of seismological knowledge was included. The Caucasus has been described as a welter of strange languages and nationalities; but if Colchis the Golden was the cradle of the infant by-product iron industry, the double lure of gold and the new discovery may well have attracted the Wise Men from the East to the new centre of metallurgical knowledge.

These incidental remarks serve as a background to the study of the crucible processes of the East, the distribution of which suggests an intercourse between races widely separated in space. It is proposed to take these processes in the following order:—(1) China; (2) India; (3) Ceylon; and (4) Japan.

China (Shansi Province)

In 1910, Prof. T. T. Read, of Columbia University, visited China, and in conjunction with two Chinese metallurgists studied the metallurgical processes in use at the Pingtinchow Ironworks in that province. The account is based upon an article in "Engineering" in December, 1910,[1] probably contributed by Prof. Read, and on later Papers by the Professor in 1924 and 1934.[2] This Shansi process is substantially unique, as it utilises the crucible both for smelting and conversion purposes.

First Operation.—The furnace dimensions are 12 ft. by 6 ft. with walls 4 ft. high, and the fuel is anthracite. The interior is packed with 4-ft. clay cylinders 5 in. in diameter, set vertically in batches of from 250 to 275 at a time. The cylinders are filled with iron ore and anthracite in about equal proportions. Smelting with natural draft occupies from 3 to 4 days. When completed the bottoms of the cylinders are broken to extract the bloom, which is treated for conversion into malleable iron. Near the upper end of the cylinders the iron varies from nut to small shot size, and this iron is preferred for conversion into cast iron.

Second Operation.—The smaller pieces of iron are transferred to dwarf crucibles, the dimensions of which are variously stated (7 in. by 14 in. dia. and 12 in. by 10 in. dia.). Probably the size varies with the foundry requirements, *i.e.*, for large castings a larger size of crucible is needed. The crucibles are filled with iron and anthracite in batches of 70 to 80 at a time and are fired with anthracite and forced draft. Cast iron is produced at the end of the operation, which probably lasts 3 to 4 hours.

Read stated that in current practice a weathered coal, called Hei-Tu, containing phosphorus, is introduced into the crucibles whereby a material reduction of the temperature for fusing the metal is effected; but his analyses of early Chinese castings disprove his suggestion that this economy facilitated the coming of cast iron.[3] An analysis of Hei-Tu is given in the "Beiträge zur Geschichte der Technik," vol. 21, p. 153.

China (Hankow District)

Here malleable iron is produced in crucibles, in batches of 60 at a time, containing 4 parts ore (magnetite) to 2 parts of small coal. Smelting with forced draft results at the end of 16 hours in the production of white cast iron, which breaks up into a brittle dust, and pieces of softer iron. The latter are refined in a wood fire.[4]

While the details of the Shansi process are still fresh in mind, the story passes to ancient India, allowing a comparison of these two processes to be made. The principal seat in the past of the Indian cast-steel process was in what is now the Nizam's Territory, or the State of Hyderabad. An obscure description of this process is contained in the abridgment of the Indika of Ktesias. The original, which is lost, was composed about 400 B.C., but an abridgment by Photius has survived, made some 1,200 years after the date of the original. The following translation has been made from the text of the Göttingen edition of 1823.[5]

> "Concerning the Spring, which is filled every year with alluvial gold, from which 100 earthen pitchers are drawn up annually. The pitchers must be earthen since the gold when withdrawn is in a solid state, and it is necessary to break them to extract it. The Spring is of a square shape with a perimeter of 16 cubits (*i.e.*, 24 ft.) and a fathom (*i.e.*, 6 ft.) in depth. Each pitcher weighs a talent (*i.e.*, 0.57 lb.).
>
> "And concerning the iron found at the bottom of the Spring, Ktesias says that from it he had in his possession two swords, one a gift from the King, and the other from the King's mother, Parysatis. He says of this iron that, if fixed in the ground, it wards off clouds and hail and thunderstorms, this he says, he witnessed himself, the King officiating on both occasions."

Commentators on the Indika, including Dr. Beck,[6] the metallurgist, have suggested that the so-called Spring of Ktesias must from its dimensions be regarded as a smelting furnace rather than a cistern or tank,[7] and now, using the account of the Shansi process as a guide, one may safely assume the pitchers to be crucibles.[7] Their number, 100 against Shansi's 250 to 275, and weight, when filled with ore and fuel, are both reasonable, and the design and dimensions of the furnace correspond closely with what is known of the Persian model.

A personal conclusion is that Ktesias entirely failed to grasp the basic principle of the process told him, but correctly recorded the dimensions. One is therefore concerned with the account revealed behind the text rather than with the text itself. The following amendments, however, seem necessary: In paragraph 1 to read "alluvial iron and gold" and in paragraph 2 "iron" instead of "gold." Applied to gold the statements are meaningless; but apart from this the text itself requires these changes; for in the final portion of the narrative Ktesias most unaccountably switches over from gold to "the iron found at the bottom of the Spring," showing that he had really been dealing with iron throughout. Possibly his abridger, Photius, thought that gold made a better story of it.

There is no direct evidence as to the Hyderabad second-operation or conversion process, but if it is legitimate to include the Chalybean process in the crucible class, because the steel was said to be indistinguishable from silver, the same reasoning would apply to the Hyderabad process, since the Indian steel was described by Quintus Curtius as "Ferrum Indicum candidum."[8] This writer tells us that Alexander the Great, after his defeat of two warlike tribes, demanded an indemnity of 100 talents of steel, that is about 2½ tons. This may have been an estimate of the quantity which disarmament of the tribes would yield, and is, no doubt, greatly in excess of that surrendered. It assumes, however, that the industry was a large one. That the account of Ktesias relates to the Hyderabad first or smelting process may be inferred since in the conversion process much smaller crucibles were used.

Furnace Details

Another account of the conversion process as practised in the Nizam's Dominions occurs in the Voysey MSS.[9] The operation was observed at Kona Samundor, 12 miles south of the Godaveri River and 25 miles from Nirmul.

The furnace is a circular structure of clay, 4 to 5 ft. high and 5 ft. in diameter, sunk 2 ft. below the surface of the ground. The iron is converted in pine-shaped crucibles, the size of which varies with the purpose for which the steel is intended. A granitic clay is used mixed with ground crucible and kneaded with chaff of rice and oil. The tops of the crucibles are sealed. No charcoal is put in, but small pieces of glassy slag called "Kansh" are placed in their bottoms to serve as a flux. Two kinds of ore are used, magnetite and clay iron ore. The steel cake is covered with clay before annealing. The furnace temperature is given as C. 130 Wedgewood, which according to figures kindly supplied by Dr. Goldsmith might be as high as 1,400 deg. C.—a temperature seldom attained in the bloomery furnace.

If Voysey's account be correct the Hyderabad process must have differed from those further south, both as regards the size and construction of the furnace, and the contents and disposition of the crucibles. Buchanan's account is known by the abridgment in Dr. Percy's "Iron and Steel."[10]. The above processes anticipate Huntsman in several respects, the ashpit sunk below the hearth, the manner in which the flame is brought to the crucibles, and still more remarkably in the use of a flux. Huntsman at first used bottle glass, but abandoned it.

* One of a series of Papers (here slightly abridged) presented to the Newcomen Society for the Study of the History of Engineering and Technology, of which the author is Vice-President.

Buchanan's account is corroborated by Heyne.[11] The two supplement one another materially. Wilkinson[12] said that the steel of the Carnatic was inferior to that of Hyderabad; but the Wootz steel industry was already on the downgrade at the end of the 18th century, when the subject of Indian steel first attracted the attention of the learned.

Ceylon

Ceylon follows generally the Indian practice. Chips of Cassia auriculata are filled with the iron into crucibles in the proportion 12½ oz. of iron to 5 oz. of the wood. The crucibles are clay tubes 8 in. long, 2 in. in diameter and 14 in. thick. Blowing is stopped during the conversion operation to enable the crucibles to be turned round. The product is a rod of cast steel. Coomaraswamy's account,[13] however, was based on a trial smelting arranged specially for the purpose of his 1904 report. At that date the industry was moribund. Hence the number of crucibles commonly used at a time is not stated.

Japan might logically be omitted from the purview of this Paper on the ground that its processes for steelmaking are not based upon the crucible principle. Gowland's account[14] is incomplete. A fuller and more accurate statement by B. S. Lyman will be found in the Progress Reports of the Geological Survey of Japan, 1878-79, pp. 60-78. Rd. Andree's "Die Metalle bei den Naturvölkern"[15] will also be found useful.

Japanese Practice

The Japanese furnace is of a low horizontal section, forming a V-shaped trough pierced on both sides with tuyeres, and with a hole at each end of the trough for drawing off slag and pig-iron. Owing to the high temperature generated by the blast the furnace walls are rapidly corroded. During the first two days' blowing, some slag and pig-iron run out. In course of the third day the blast is stopped and the mass consisting of good and bad steel and pig-iron is extracted. A feature of this process is that an increased demand can be met by the addition of fresh units, *i.e.*, by a horizontal extension of the system, and this without loss of quality in the product. In Europe the reverse was the case. The vertical raising of the furnace walls was attended by a successive deterioration in the quality of the iron.

Gowland's remarks on the Japanese system are singularly inappropriate. True, the furnace walls had to be rebuilt after each operation, but their foundations were of a permanent character and might last a century.

The Rachette horizontal copper-smelting furnace was based on the Japanese principle. Models were exhibited in the Russian pavilion in the London Exhibition of 1862. The furnace was operated with success, and it was proposed to extend the system to iron smelting, but Dr. Percy was unable to state whether this had been done.[15]

Rd. Andree[16] distinguishes between the horizontal furnace intended for smelting magnetite grains and the vertical furnace for treating mined ore, which he compares to the *Stück-ofen*. This could be worked by hand blast or by the platform bellows illustrated in Gowland's Paper.

Japan, however, had its crucible process. Kaempfer[17] says "Iron is dug up only upon the confines of the three provinces, Mimasaka, Bitsju and Bisen, but it is found there in very large quantities. It is refined upon the spot, and cast into staffs or cylinders, 2 span long (*i.e.*, 1 ft. 6 in.). Japanese merchants buy it at the place and export it all over the Empire. It is much of a price with copper, iron tools being full as dear or rather dearer than those of copper and brass. . . . They do not dress their victuals in brass pans, but have a particular sort of kettles or pans which are made of a composition of iron, and are pretty thin. The old ones of this sort are very much esteemed, and bought at a great rate, they having somewhat particular in their shape and make, which at present they have lost the art to imitate." These thin cast-iron kettles or pans are probably the Chinese hollow-ware described by T. T. Read,[18] which the Chinese regard as valueless. Yet they were being picked up as curios by the Japanese in the 17th century!

Before quitting Japan reference must be made to a passage in Mandelslo's Travels[19] in that country in 1639, which runs as follows:—"They (the Japanese) have, among others, a particular invention for the melting of iron, without the using the fire, casting it into a tun done about on the inside with about half a foot of earth, where they keep it (melting) with continual blowing, and take it out by ladles full, to give it what form they please, much better and more artificially than the inhabitants of Liége are able to do."

Bessemer Process Anticipated

Whether or not this passage did, or as Dr. Percy thought, did not constitute an anticipation in law of the Bessemer invention it is not proposed to discuss. Since the publication of Dr. Percy's "Iron and Steel" knowledge of Far Eastern metallurgy has grown materially. The iron referred to was, no doubt, white or mottled pig, which contains sufficient combined carbon to generate the heat required to keep the metal molten. At what point in the converter the blast was introduced is not stated; but Gowland's figure of the Japanese moving platform blower[14] shows that their apparatus was an efficient one. Hence it is clear that the principle of the Bessemer process was known to Japanese practice a couple of centuries before it was brought to fruition in this country.

This concludes the survey of the crucible processes of the East. From it the history of the iron manufacture may be outlined as follows:—Iron is first discovered in the bath of molten gold. Its identification with meteoric iron quickly follows, and its source is traced to the black sand of the rivers and streams. The magnetite is now collected and the preference shown for this ore is maintained throughout the history of the Eastern iron industry.

For converting iron into cast steel the crucible process was the only practicable one: but according to Ktesias large crucibles were used for smelting the ore also. Obviously it would be dangerous to lean too heavily on Ktesias's account, but it is not incredible; for until the Indians had learned a way to reduce granular magnetite in the open hearth, crucible smelting, though uneconomic, may have prevailed. Its survival in Shansi is explained by the abundance of anthracite in that Province.

The Wootz steel process differed from all others by two peculiarities. Carbon was introduced into the crucibles in the form of the wood and leaves of specific plants which were held to be indispensable to success. Moreover, Wootz steel was unique in its production of the Damascus pattern, which the author has suggested originated in a humble imitation of the crystalline (octahedral) structure of meteoric iron.

Taken as a whole the processes of the East may be described as more flexible than those of contemporary Europe. They were based on the control of a higher range of temperatures, and denote a deeper insight into the principles of iron metallurgy.

In the next instalment of this Paper the author will deal with questions of priority, place and date of the invention of crucible steel. It may also include a sketch of the route by which ironmaking arrived in Britain, and of the metallurgical arts of the Iron Age people who were the first makers of iron in this country.

(*Continued in next column.*)

Some Points in Casting Production

(*Continued from page* 379.)

the sulphur present in the metal, the element promotes the increase and stability of the carbides. The minimum manganese necessary to balance sulphur is 1.72 parts of manganese to one part of sulphur. An excess is necessary above molecular ratio to ensure effective sulphur contact throughout the metal and avoidance of inverse reactions.

The element lowers slightly the freezing point and increases the fluidity of metal of low and moderate silicon content. It increases strength, density and hardness, whilst shrinkage increases. Cast iron containing between 1 and 1.5 per cent. manganese takes on a high polish.

Sulphur

Pure iron readily combines with sulphur to form iron sulphide (FeS). In the presence of other elements contained in cast iron, such as silicon and manganese, the sulphur absorption is reduced. The influence of sulphur will vary according as to whether combined with manganese or with iron as sulphides. Sulphide of manganese is insoluble in molten iron and will, therefore, exert no influence on the condition of the carbon. Iron sulphide is soluble in molten iron down to the freezing point with strong tendencies to prevent graphite formation by stabilising the carbides. A percentage of 0.01 of sulphur may prevent the formation of 0.2 per cent. of graphite, or one part of sulphur retards the formation of 20 parts of graphite.

The element increases hardness and shrinkage due to the stabilisation of the carbides. It reduces the freezing range, increases viscosity and creates a tendency to blowholes from gas evolved at the freezing point of the metal. The sulphide compound holds gases in solution until near the freezing point. Iron sulphide with a low freezing point, below 1,000 deg. C., has a strong tendency to liquate and segregate, creating irregularity and hard localities in the metal.

Having now roughly outlined the general view of the heterogeneous metal, cast iron, one may more easily appreciate why it is possible considerably to influence the structure of the metal by the nature of the mould constructed to receive it. The rate of freezing and the condition and retentive power of the mould walls are of major consequence.

(*To be continued.*)

(*Continued from previous column.*)

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[1] "Engineering," vol. 90, Dec. 2, 1910, pp. 761-2, 2 pl. (12 figs.).
[2] "Iron Age," vol. 108, 1921, p. 451, illus.; T. T. Read, "The Early Casting of Iron in China," in "Geograph. Rev.," Oct., 1934, pp. 544-54.
[3] T. T. Read, *ibid.*
[4] "Iron and Coal Trades Review," vol. 86, May 23, 1913, p. 853.
[5] H. H. Wilson, "Notes on the Indica of Ctesias," in Ashmolean Society (Papers), 1836, 80 pp., and Ctesias Ancient India, Trsl. J. W. Crindle, from the "Indian Antiquary," 1881, with additions (London, 1882), should be consulted.
[6] L. Beck, "Geschichte des Eisens," 1, p. 229.
[7] To the proposed amendment it may be objected that in very early times cisterns were used for gold washing in arid regions. *Cf.* C. E. N. Bromehead's valuable Paper on "The Evidence for Ancient Mining," in "Geograph. Jl.," Aug., 1940. The statement in the opening sentence in Ktesias, when applied to magnetite, is corroborated in Fr. Buchanan's "A Journey from Madras, etc.," vol. 2, p. 20, where it is pointed out that the collection of magnetite in India is done during the four rainy months when sufficient ore can be collected by four men to supply a furnace during the remaining eight.
[8] Quintus Curtius, "History of Alexander the Great," vol. 2, p. 350.
[9] Reproduced in the Journal of the Asiatic Society, vol. 1, 1832.
[10] J. Percy, "Metallurgy: Iron and Steel," 1866, pp. 773-4.
[11] B. Heyne, Tracts . . . on India, xxiv, Account of the method of making steel in the Mysore country, 1814, pp. 358-64.
[12] H. Wilkinson, "Engines of War," 1841, pp. 201-4.
[13] Ceylon Administration Report . . . Mineralogical Survey of Ceylon, 1904, E, pp. 5-6.
[14] W. Gowland, "The Early Metallurgy of Copper," etc. In "Archaeologia," vol. 56, May, 1899, pp. 305-9, 3 figs.
[15] J. Percy, *op. cit.*, p. 490.
[16] Rd. Andree, "Die Metalle bei den Naturvölkern," Leipzig, 1884, p. 113.
[17] E. Kaempfer, "History of Japan," 1690-2. Trsl. J. G. Scheuchzer, 1727, Glasgow, re-issue 1906, vol. 1, p. 171.
[18] T. T. Read, "Primitive Iron Smelting in China," "Iron Age," vol. 108, 1921, p. 451.
[19] E. Clibborn on the partial combustion of fluid iron described by Mandelslo in 1639, etc., in Trans. Roy. Irish Acad., May, 1862. J. Percy, *op. cit.*, p. 816.

FIG. ON RO

Vanadium in Cast Iron

By E. PIWOWARSKY

(*Translated from "Die Giesserei."*)

(*Continued from page* 364.)

Vanadium in Cast Iron for Rolls

According to a publication of June, 1932,[5] prepared by J. Challansonnet for A.S. Bremanger Kraftselskap, the use of vanadium-titanium iron in cast-iron rolls effects, in the case of 0.3 per cent. V, an increase in hardness of the surface from 500 to 700 Brinell with an increase in the depth of chill by 12 to 25 per cent. and a marked reduction in the abruptness of the transition to the mottled or grey inner zone. In this publication, a vanadium-titanium iron with 3.2 per cent. C, 1.2 to 1.6 per cent. Si and 0.6 per cent. Mn is recommended for hot rolls. For cold rolls, a 15 per cent. proportion of a vanadium-titanium iron with 4.2 per cent. C, 0.3 to 0.4 per cent. Si and 0.2 per cent. Mn is recommended in the charge.

These remarks are, however, not in agreement with the experimental results of K. Taniguchi,[97] who, with increasing addition of vanadium, found that the latter tended rather to produce a diminution in the surface hardness of

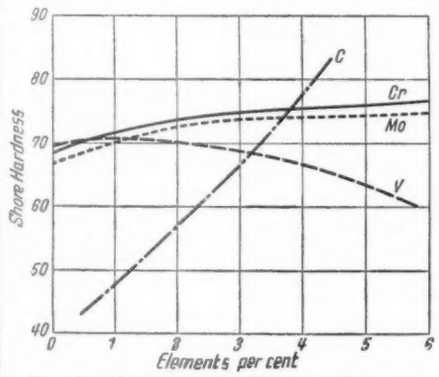

FIG. 9.—INFLUENCE OF VARIOUS ELEMENTS ON THE SURFACE HARDNESS OF CHILLED ROLLS. (TANIGUCHI.)

cast-iron rolls (Fig. 9). On the other hand, Taniguchi found a marked increase in the depth of chill (Fig. 10).

Both influences are explicable on the hypothesis of the binding of carbon by insoluble vanadium carbides, especially since in this case also they agree in order of magnitude with the effects verifiable by calculation. That is to say, vanadium in this case does not produce any effect other than that which would be produced merely by reducing the carbon content. The use of vanadium would, nevertheless, be advantageous in the case of chilled rolls if, for instance, the resistance of hot rolls to high temperatures could be increased by economically supportable additions. Since, furthermore, in cast-iron rolls, it is important to have a surface free from pores but of high density, vanadium would, by its deoxidising effect alone, produce advantages which would appear to justify its use in cast iron for rolls.

Heat-Resisting Properties, Resistance to Scale Formation and Constancy of Volume

In alloys resembling steel, even low contents of vanadium (0.1 to 0.2 per cent.) have a favourable effect on the heat-resisting properties.[22] The possibility of improving the heat-resisting properties and resistance to scale formation of cast iron by the addition of vanadium is denied by some, and is regarded as promising by others.[12] Vanadium alloy pistons are said to be conspicuous for their very small growth. Vanadium alloy moulds for the vulcanisation of rubber and castings for glass moulds are stated to have given excellent service.[12] The prospects are also very promising for centrifugally-cast liners and piston rings. In addition to good heat-resisting properties, a reduction in wear is to be expected. In engine and pump construction and in the manufacture of steelworks' ingot moulds, the use of vanadium is promising. With a tensile strength of 15 to 20 per cent. higher, vanadium-titanium alloy engine parts are said to have given better behaviour at high temperatures (525 to 450 deg. C.). A Belgian works,[13] employing a cupola

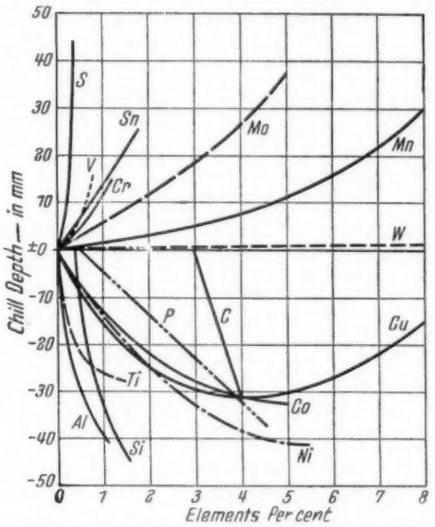

FIG. 10.—INFLUENCE OF VARIOUS ELEMENTS ON THE CHILL DEPTH OF GREY IRON. (TANIGUCHI.)

charge consisting of 50 mould scrap, 35 hematite pig and 15 per cent. vanadium-titanium iron (4 per cent. C, 2 to 2.5 per cent. Si), produced ingot moulds having a life increased by 25 to 70 per cent.

Table VII also shows that vanadium-titanium alloy cast iron, when tested for tensile strength at 400 deg. C., often gave higher values than corresponded to those obtained at room temperature.

Wear and Running Properties and Behaviour at High Temperatures

With regard to diesel-engine liners made with 25 per cent. vanadium-titanium iron, the wear of a Sulzer two-stroke diesel engine (3,000 h.p.) was reduced, after 9,000 to 11,000 service hours, from originally between 3.2 and 3.9 mm. to between 1.7 and 1.1 mm. Each curve in Fig. 11 represents the mean wear of six cylinder liners.[14] It should be borne in mind that a differentiation in the tendency to wear only appears after the pistons have been run in. Due to the use of Norwegian vanadium-titanium iron, the liners were always high in carbon and contained more than 3.4 per cent. C. Resistance to wear and running properties were, however, more satisfactory with the vanadium addition.

The Chemin de Fer de Paris à Orleans[15] employ vanadium-titanium iron for locomotive steam-engine cylinders, piston rings, piston valves, etc., resulting in a longer period between two successive inspections (*e.g.*, 40,000 kilometres as against only 15,000 kilometres in the case of piston valves), due to the higher resistance to wear of the castings.

Vanadium in Nitriding Cast Iron

The vanadium nitrides V_2N and VN are very stable. VN, which melts at about 2,000 deg. C., exhibits even at that temperature merely incipient decomposition, and the stability of the vanadium carbides is very high even in ferro-vanadium.[20] According to K. Wendt,[21] a considerable increase in hardness is to be expected in nitriding steels. In view of the practically complete binding of the vanadium in the form of carbide or nitride, even higher vanadium contents would have scarcely any influence on higher carbon iron. J. Challansonnet,[16] however, on comparing the nitriding properties of a chromium cast iron with a vanadium cast iron, found that with otherwise constant composition, the differences in the hardness and change of hardness are not great (Fig. 12). The two irons had the following compositions:—

Iron I.—C, 2.33; Si, 1.62; Mn, 0.40; V, 0.27; Cr, —; Mo, 0.60; Al, 1.50; and Ti, 0.10 per cent.

Iron II.—C, 2.5; Si, 1.50; Mn, 0.40; V, —; Cr, 0.25*; Mo, 0.60; Al, 1.25 per cent.; and Ti, not determined.

The vanadium melt was prepared by adding 45 per cent. of vanadium-titanium Norwegian pig. After nitriding (70 hours at 530 deg. C.), the following hardness values were obtained:—Vanadium alloy: Depth of nitration, 0.30 mm.; surface hardness, 70 Rockwell and 800 Vickers. Chromium alloy: Depth of nitration, 0.35 mm.; surface hardness, 79 Rockwell and 875 Vickers.

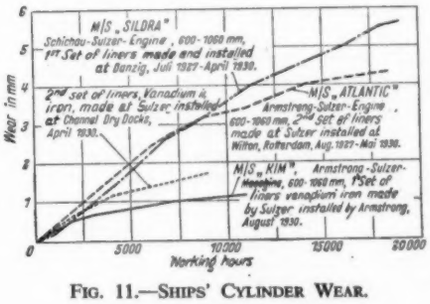
Wear in mm
Working Hours
M/S „SILDRA"
Schichau-Sulzer-Engine, 600-1060 mm,
1st Set of liners made and installed at Danzig, Juli 1927-April 1930.
2nd set of liners, Vanadium iron, made at Sulzer installed at Chennel Dry Docks, April 1930.
M/S „ATLANTIC"
Armstrong-Sulzer-Engine, 600-1060 mm, 2nd Set of liners made at Sulzer installed at Wilton, Rotterdam, Aug. 1927-Mai 1930.
M/S „KIM", Armstrong-Sulzer-Engine, 600-1060 mm, 1 Set of liners vanadium iron made by Sulzer installed by Armstrong, August 1930.

FIG. 11.—SHIPS' CYLINDER WEAR.

Vanadium in Malleable Cast Iron

As in the case of cast iron, the author[11] has also investigated the influence of vanadium on the properties of malleable iron (whiteheart and blackheart), the addition of vanadium being effected in the form of vanadium-titanium pig. The result may be stated to be that an addition of only 0.05 to 0.10 per cent. V leads to a high-grade, very wear-resistant malleable iron having a sorbo-pearlitic final structure. Although, for instance, unalloyed malleable iron (blackheart) under the selected conditions of production and heat-treatment (in the laboratory and unfavourable) had a tensile strength of 38.5 kg. per sq. mm., together with an elongation of only 3.6 per cent. and impact energy of 1.43 mkg. per sq. cm., it was possible, by way of comparison, in the vanadium irons with a tensile strength of 50 to 56 kg. per sq. mm., to attain elongations of 3.8 to 4.25 per cent. and impact values of 1.45 to 2.80 mkg. per sq. cm.

Method of Adding Vanadium

When Norwegian vanadium-titanium iron was used in the cupola charge,[11] there were titanium losses of 40 to 80 per cent., while the melting loss of vanadium was 5 to 20 per cent. Various authors have given melting loss figures

* This should surely be 1.25 per cent. If comparison of the two materials is to have any meaning.

of between 30 and 80 per cent. for the addition of high-percentage ferro-vanadium (low in silicon and carbon). These high figures will undoubtedly be reduced to 20 to 30 per cent. by adding the vanadium to a previously deoxidised molten cast iron, especially when employing readily soluble ferro-vanadium alloys, in the form of a 40 to 42 per cent. ferro-vanadium with about 8 to 10 per cent. silicon. Further experiments will be necessary to show whether, in view of the high affinity of vanadium for oxygen, it will be possible to employ successfully the known method using exothermic packets. In the addition of vanadium to molten steel, losses of 2.5 to 33 per cent. have been found,[28] according to the metallurgical conditions and the type of furnace.

Segregation in Material Containing Vanadium

Assuming that in the presence of an excess of carbon, practically the whole of the vanadium separates out in the form of carbide before solidification, considerable ingot segregation is to be expected in view of the specific gravity of vanadium carbides of 5.3 to 5.5.[29]

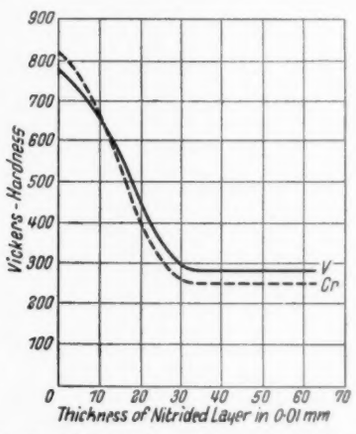

FIG. 12.—VANADIUM IN PLACE OF CHROMIUM IN NITRIDING CAST IRON. (CHALLANSONNET.)

In point of fact, even in steel, considerable accumulations of vanadium carbides have been observed[30], and, of course, the same is to be expected to a greater degree in the case of cast iron. According to Roll,[31] in casting ladles of about 1 ton, segregation is so extensive that it not only leads to considerable carbide nests in the casting, but even before pouring there is a strong accumulation of vanadium in the upper part of the casting ladle.

Determination of Vanadium in Cast Iron

In iron and steel, vanadium is determined either gravimetrically (by oxidation) or potentiometrically.[32] The gravimetric method is inapplicable in the presence of more than 6 per cent. Cr. Some time ago, H. Pinsl[33] developed a photometric method of determining vanadium by means of the Pulfrich photometer, which is used by numerous foundries for the determination of vanadium in cast iron. Whether this application of the method is justified will require further experiments, which it is to be hoped will produce a basic method for the determination of vanadium in cast iron. In cast iron free from chromium and molybdenum, the potentiometric and photometric methods apparently give perfectly concordant results.

Summary

Contents of 0.08 to 0.35 per cent. come into consideration for the alloying of vanadium with cast iron. Vanadium exhibits a great tendency to loss through oxidation, and it should be added with the greatest of care. Vanadium is a very powerful promoter of carbide formation, and the carbide promoting influence appears to be more pronounced, the lower the carbon and silicon content of the iron, the harder the melting furnace is driven and the thinner the walls of the casting (rate of cooling). Additions of up to about 0.3 per cent. alter the structure of cast iron only slightly. The pearlite apparently tends increasingly towards a sorbitic form (the pearlite point on cooling is scarcely affected by vanadium additions). Above about 0.3 per cent. V free carbides occur. These have a spherical form, tend to increase ingot segregation and impair the casting properties. The commencement of temper carbon formation is raised by about 30 to 40 deg. C. for each 0.1 per cent. V. The mechanical properties of normal sorts of cast iron are appreciably improved by the addition of vanadium, the tensile strength being increased by about 2 or 3 kg. per sq. mm. for each 0.1 per cent. V. In the case of mechanically very high grade iron (tensile strength above about 20.3 tons per sq. m.), vanadium has only a slight positive influence, while above about 22.8 tons per sq. in., vanadium has sometimes even an adverse effect. Freedom from gas and density are undoubtedly increased by the addition of vanadium. Numerous effects of vanadium in cast iron can be explained by the fact that the vanadium carbides, which are only slightly soluble in molten iron, if at all, remove carbon from the material, thus displacing the entire iron-carbon diagram to the right. Even the resistance to heat, especially between 400 and 500 deg. C., appears to be somewhat improved, as is also the resistance to wear. In chilled cast iron (cast-iron rolls), the hardness of the surface is apparently improved to a lesser extent than its cleanness and freedom from pores, and perhaps also the toughness of the carbide zones. The effect of vanadium in regulating the depth of hardened zone would appear to resemble that of a diminution of the carbon content. The influence of vanadium on the resistance to scale formation has not yet been fully elucidated, but it would scarcely appear that any special advantages are to be expected. The effect of vanadium in nitrided cast iron appears to be similar to that of chromium, but further investigation of this point is necessary. Up to the present, additions of vanadium have given more or less satisfactory service in the production of cylinder liners, piston rings, high-strength machine castings (locomotive castings, gas-engine castings, dies, grinding and crushing machines, pistons, plungers, punches, etc.), chilled cast-iron rolls (cold and hot rolls), ingot moulds, glass moulds and possibly also fire-bars. For heat-resisting castings, in conjunction with nickel or molybdenum, it is possible to produce castings which are heat-resistant and of constant hardness and volume up to about 650 deg. C. In general, however, vanadium appears to be able to replace the element chromium rather than molybdenum in cast iron. Table X gives some examples of the composition of vanadium cast iron as adapted to American practice.

TABLE X.—*Composition of Types of Vanadium Cast Iron (Vanadium Corporation of America).*

Use.	T.C. Per cent.	Gr. Per cent.	Carbide carbon. Per cent.	Si. Per cent.	S. Per cent.	P. Per cent.	Mn. Per cent.	Ni. Per cent.	Cr. Per cent.	Cu. Per cent.	Ti. Per cent.	Mo. Per cent.	V. Per cent.
Glass moulds ..	3.30	2.70	0.60	1.65	0.07	0.30	0.60	—	—	—	—	—	0.15
Fire-bars ..	3.70	—	—	1.70	0.09	0.45	0.55	—	—	—	—	—	0.15
Dies	3.40	2.50	0.90	1.30	0.07	0.25	0.50	—	—	—	—	—	0.15
Dies	3.40	2.60	0.80	1.00	0.10	0.30	0.80	—	—	—	—	—	0.25
Bronze rolls ..	3.00	—	—	0.80	—	—	0.30	—	—	—	—	—	0.25
Locomotive cylinder blocks ..	3.45	—	—	1.55	0.10	0.50	0.55	—	—	—	—	—	0.15
Brakedrums ..	3.15	—	—	1.90	0.10	0.20	0.65	—	—	1.50	—	—	0.10
Brakedrums ..	3.05	—	—	1.85	—	—	—	1.25	—	—	—	0.75	0.15
Moulds for chilled castings ..	3.30	—	—	2.20	0.10	0.25	0.70	—	—	1.50	—	—	0.10
Moulds for chilled castings ..	3.30	—	—	2.20	0.10	0.25	0.70	—	0.50	—	—	—	0.10
Diesel cylinder heads	3.00	—	—	2.10	—	—	—	—	—	—	—	0.50	0.10
Diesel cylinder heads	3.05	—	—	1.85	—	—	—	1.25	—	—	—	0.75	0.10
Diesel cylinder heads	3.00	—	—	1.85	0.10	0.20	0.75	—	—	—	0.20	—	0.10
Motor-car cylinder heads ..	2.85	2.35	0.50	1.70	0.10	0.30	0.40	0.85	—	—	—	—	0.10
Piston rings ..	3.70	—	—	2.70	0.08	0.35	0.70	—	—	—	0.15	—	0.10
Dies	3.60	—	—	1.40	0.09	0.25	0.50	2.00	0.70	—	—	—	0.15
Dies	3.50	—	—	1.25	0.08	0.20	0.60	1.50	—	—	—	—	0.15
Steelworks rolls	3.50	—	—	1.00	—	—	0.50	—	1.75	—	—	—	0.20
Steelworks rolls	3.50	—	—	1.10	—	—	1.20	4.00	1.85	—	—	—	0.35
Hot tools ..	3.20	2.60	0.60	1.00	—	—	0.70	0.40	0.40	—	—	—	0.10
Grab plates ..	3.10	—	—	2.00	—	—	—	—	0.35	—	—	—	0.10

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U.S. Stainless-Steel Producing Plant

The annual consumption of stainless steels in the U.S.A. is now more than 2½ lbs. for each of the 130,000,000 population, it was stated during the open-house inspection of a new £500,000 addition to the Rustless Iron & Steel Corporation's works at Baltimore, Md. The works (described in "The Iron Age" as "the only establishment in the world devoted exclusively to the production of stainless steel") has an ingot capacity now of 75,000 tons a year. Three 12-ton and two 16-ton electric furnaces make up the melting plant. Capacity is four times that of five years ago, and has been nearly doubled since 1937. Employees number 1,400.

For High Quality Castings

The increasing demand for high-strength close-grained iron castings calls for improved metal. In comparison with the accepted standards of the past, the modern high quality casting requires lower total carbon and phosphorus, with a closer range in silicon. The Ironfounder can now meet this demand at a reasonable cost by the use of Stanton-Dale Refined Pig Iron.

Stanton-Dale is a pig iron of low total carbon, the graphitic carbon being uniformly distributed and of fine curly-flake formation. The close structure ensures remarkably high strength with good machineability, and Tensiles of 16 to 20 tons can readily be obtained when a proportion of Stanton-Dale Iron is introduced.

The use of this iron avoids the irregularities in structure which are sometimes observed when steel scrap has formed part of the charge.

The correct grade of Stanton-Dale Iron to use depends on the type and class of castings to be made. The Stanton Technical Service is available to advise on suitable mixtures.

Total Carbon from 2.6 per cent. upwards. *Analysis to individual specification as required.*

STANTON-DALE
REFINED PIG IRON

The Stanton Ironworks Company Limited, Near Nottingham

The Largest Producers of Foundry Pig Iron (for Sale) in Great Britain

Problems in Foundry Metallurgy

A DISCUSSION BY SOUTH AFRICAN FOUNDRYMEN

Members who attended the meeting of the South African Branch of the Institute of British Foundrymen, held in Johannesburg in September, had the privilege of listening to an illuminating Paper by MR. J. TONGE, entitled "Questions and Answers in Foundry Metallurgy."

Mr. Tonge, who is a lecturer in the subject, gave examples of the type of questions which he considered suitable for setting to students in the first-year Foundry Metallurgical Course, together with answers which in his opinion should be sufficient to satisfy the examiner. He reminded the meeting that the questions had to be answered by boys, and, furthermore, that only 20 min. were allowed for each question.

Publication of the Paper is being withheld while the examinations are pending, but some indication of the nature and quality of the Paper may be gained from the appreciative remarks of Mr. Nimmo Dewar and Mr. Davidson, and from the ensuing discussion.

Need for Clear Thinking

MR. NIMMO DEWAR said that the subjects described by Mr. Tonge in his answers were explained so simply that many members must have wondered how it could have taken them so long even to appreciate the subject matter. For instance, in dealing with rolling mills, Mr. Tonge explained a point relating to shrinkage which was often omitted from these descriptions. Metallurgy and the handling of steel were subjects of paramount national importance at the present time, and the necessity for clear thinking was very great. Since the inception of the peak year of 1929 there had never been so much steelmaking nor so many different steel products manufactured. Mr. Tonge had mentioned the use of other metals in guns and shells, etc. Never had there been a human effort on such a scale as the present armaments' production in Europe and the United States. Even in South Africa, and more especially on the Rand, there was an exceptional opportunity of seeing the metallurgist working at full pressure.

Thanks to the Institute of British Foundrymen (South African Branch), they could congratulate themselves on having men who were able to state the position as clearly as Mr. Tonge, particularly because the younger generation now being trained required instructors who could talk to them in a simple manner about subjects which, unless clearly stated, were not easily comprehended.

MR. D. M. DAVIDSON also expressed his appreciation of Mr. Tonge's excellent questions and answers. He would like to see them published for the consideration of both examiners and students; this would constitute a forward step in the technical education of young persons.

MR. TONGE thanked Mr. Nimmo Dewar and Mr. Davidson for their complimentary remarks, and asked whether the meeting considered that the lectures were on the right lines. He mentioned that last year his students were particularly fortunate in securing 100 per cent. passes, 5 per cent. with distinctions, and one South African Cup. He would welcome any suggestions as of inestimable value to a lecturer on the subject.

Sprigging in South African Foundries

MR. STONES wondered why South African founders made a practice of sprigging every casting.

In reply, MR. TONGE declared that as fine castings were made in South Africa as overseas, although in Great Britain close on a million pounds a year was spent on sand. In overseas foundries sands which were proved and tested could be bought. South African founders had to use more or less synthetic sands, and in some cases had even to make the best of whatever sand was available. They could thus be forgiven for sprigging or adopting any other means of producing a good clean casting. He agreed with another member that one of the reasons why South African castings were not quite as fine as engineers would like them to be was because of the high percentage of oxide of iron contained in local sands.

Coal-Dust Additions

MR. ALEXANDER asked for an opinion on the practice of adding coal dust to sand.

MR. TONGE recalled that the use of coal dust had fallen into disfavour some years ago, but now—like the Bessemer converter—was coming into its own again. Not only did coal dust help permeability, but it also formed a film over the sand which was a protective coating against the inrush of metal during pouring.

MR. HOLDSWORTH said he had no doubt that all British-trained moulders were convinced of the necessity for using coal dust. When he came to South Africa, he found that coal dust was not used in the establishment where he was working, but he gave it a trial and it proved very successful. He was strongly of opinion that the use of coal dust was the only means by which grey iron castings could be improved. On the other hand, he considered that sprigging indicated a lack of confidence in the sand. As a foundry foreman in charge of apprentices who were future moulders, he felt that Mr. Tonge's questions and answers were ideal.

MR. TONGE inquired whether any of the iron foundries used manure. In the old days it was a regular practice to use a percentage of dry manure which when burnt increased permeability and porosity, and assisted the ready escape of gases.

Foundry Practice in Britain

MR. MARTIN (a visitor) expressed his appreciation of the Paper. This was the first foundrymen's meeting he had attended in South Africa, and he had enjoyed it at least as much as any meeting to which he had been in Britain. Regarding coal dust, Mr. Martin referred to the practice of one of the largest grey iron foundries in England, which in 1938 employed 800 moulders operating 280 moulding machines. No casting exceeded 500 lbs. In all cases castings were machine-made and only green sand was used. Since the articles produced had to be vitreous-enamelled, as perfect a finish as possible was required. The percentage of coal dust used was increased according to the weight of the casting, and ranged from 7 up to 12 per cent. Upon analysis the volatility of the coal dust was found to be about 45 per cent. Castings were made experimentally without coal dust, and it was found that a casting made in green sand without coal dust and using the same sand mixture gave a very inferior casting.

Dealing with the lines on which a lecturer should try to impart knowledge to students, Mr. Martin made a plea for more practical instruction. His criticism of the lectures he had been given in his own student days was that, while he could have sketched any design of cupola on the market in Great Britain, he acquired little knowledge of how to deal with problems which occur during actual cupola operation. Only by experience on the job itself could students learn to cope with the practical difficulties which arose.

DR. MARAIS said that he had been to a number of foundries on the Reef, some of which added coal dust in the manner of a magician adding drops of a secret remedy, with the result that the coal dust had absolutely no effect. A ration of at least 5 per cent. coal dust was needed, and a highly volatile coal was required. It was also necessary to avoid using too much coal dust. During the generation of gas, back pressure was set up which might cause the metal to be covered by a layer of carbon. During the first stages of casting there was a decrease in permeability, and only in the final stages was permeability really improved.

Sulphur Pick-up in the Cupola

Dr. Marais also mentioned various points in connection with cupola work which he was investigating. What actually happened, he asked, during the pick-up of sulphur in a cupola? The iron was really melted on top of the bed, and a fluctuation in the percentage of sulphur was noticeable in the various layers of the descending metal. The metal coming down was first preheated by the ascending gases, the actual melting taking place some distance above the tuyeres. The blast very often picked up small particles of iron which were very high in sulphur content and carried them up to the third or fourth layer of coke. Thus it would be possible to produce iron much lower in sulphur content if the passage of exhaust gases from the fire itself could be avoided. Unfortunately, however, the preheating value of the cupola would be lost if the contact between the gas and the metal were eliminated. Quite a number of cupolas had been so designed as to avoid this contact, but in all cases fuel consumption had been considerably increased.

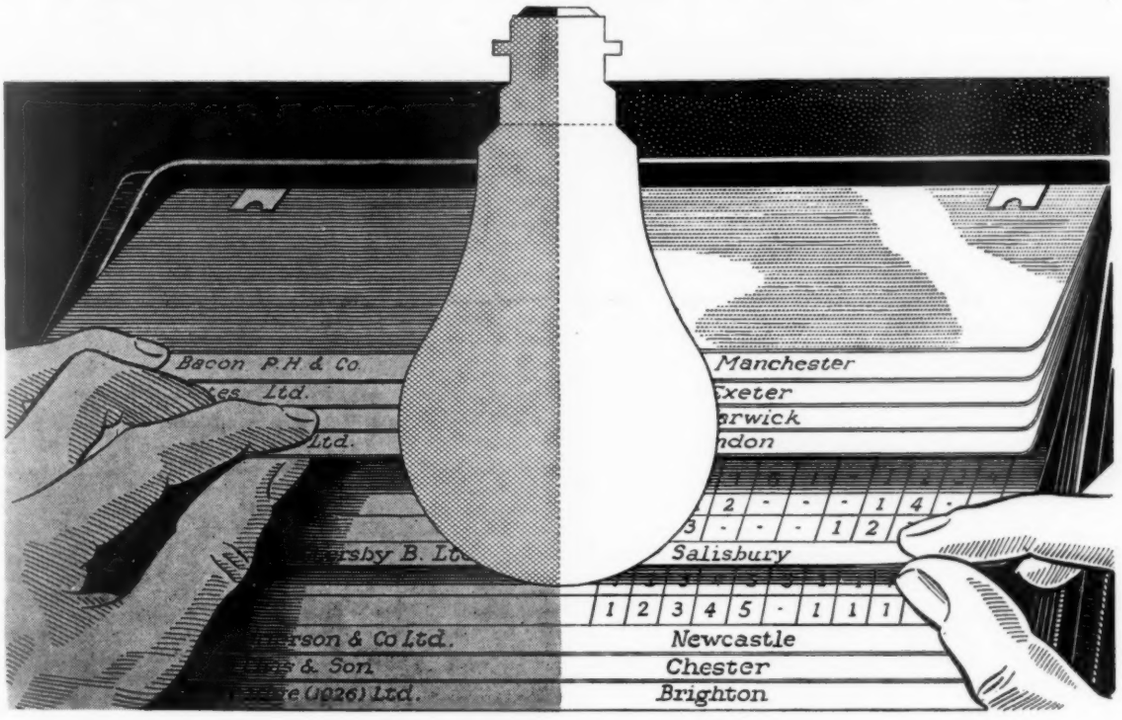
Swelling of Castings

MR. WARD said that his company was investigating a curious point in connection with the melting of white iron. Starting off with a charge of about 500 lbs., it was the practice to pig the first half-ton of metal actually melted. This was done because, about 18 months ago, it was noticed that the metal from the first half-ton cast perfectly well, but the following morning castings would be swollen. This trouble disappeared, but in order to be on the safe side it was decided to pig the metal. Recently this strange phenomenon had recurred. The defects were in the nature of tears, the staining on the inside of the tears being negligible; the skins of the castings were perfect. The silicon content was usually about 0.7 per cent. A complete analysis was being made of the defective castings, and until they had investigated further they would continue to pig the first half-ton.

Catalogue Received

Light Alloys. The "Birmal Technical Data," when published in 1935, received high commendation from this reviewer. It is not surprising to learn that it is now out of print. Instead of publishing a revised edition, Birmingham Aluminium Casting (1903) Company, Limited, of Smethwick, Birmingham, wisely decided to issue three pocket charts. Printed on stiff card folded to waistcoat-pocket size, each one is of a distinctive colour. No. 1 covers the mechanical and physical properties of aluminium alloys for pistons and for general use, and of zinc-base alloys for die-castings. The second one is similarly devoted to aluminium and Elektron (magnesium) alloys. The third one is uniform with the others, but smaller. It covers the heat-treatment of aluminium and Elektron alloys. Though of such small dimensions, the data which are presented are particularly comprehensive. So long as stocks last, copies will be sent to readers on application to Birmingham.

Light up—for efficiency!



There's no doubt about it—brighter lights mean faster, more accurate work, less spoilage and less fatigue. Light up then, with Osram Lamps. Their brilliance, their sturdiness, their reliability, will increase efficiency in every department of your business. With Osram Lamps you get what you pay for—your money's worth in light for every unit of current consumed.

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The Week's News in Brief

Trade Talk

KEIGHLEY ASSOCIATION OF ENGINEERS is holding a ladies' dinner and social evening to-morrow (Friday).

THE NOMINAL CAPITAL of Petters, Limited, oil-engine makers, has been increased by £75,000 in £1 ordinary shares to £100,000.

EMPLOYEES of Argus Foundry, Limited, Thornliebank, Glasgow, have allocated the sum of £158 to infirmaries and other charitable institutions.

THE LONDON OFFICES of the Whessoe Foundry & Engineering Company, Limited, of Darlington, have been removed from 25, Victoria Street, to Lane's Offices, Potten End, Berkhamsted, Herts. Telephone: Berkhamsted 18.

A FINANCIAL agreement has been concluded between Britain and Turkey under which, in exchange for locomotives, wagons and munitions, and textile goods, etc., Turkey will send this country agricultural and other essential products. The United Kingdom Commercial Corporation is acting as the British Government's agent in this matter.

MR. B. WELBOURN, chief engineer of British Insulated Cables, Limited, opened recently the new high-voltage laboratory in the Department of Electrical Engineering at Liverpool University. The cost of the building has been borne by the University, but the equipment has been provided through the generosity of the late Mr. G. H. Nisbett, British Insulated Cables, Limited, and the Liverpool Corporation electric supply department.

THE MINISTER OF LABOUR (Mr. Ernest Bevin) has set up a committee to advise him on labour supply questions in the North-Western Area. The members are Sir Frederick J. West (chairman), West's Gas Improvement Company, Limited; Mr. A. F. Bennett; Mr. J. H. Kearns; Mr. W. D'Arcy Madden (Hick, Hargreaves & Company, Limited); Mr. F. Robinson (National Union of Sheet Metal Workers and Braziers); Mr. Fred Siddall (Amalgamated Engineering Union); Sir Ernest D. Simon (Ministry of Aircraft Production); and Mr. E. Watson Smyth, Chief Labour Supply Officer, No. 1 Area (N.W.). This committee is peculiar to the North-West Division.

Personal

MR. D. B. HOSEASON has been appointed to the board of the Brush Electrical Engineering Company, Limited, of Loughborough.

MR. W. F. CARTWRIGHT, A.M.I.Mech.E., has been appointed chief engineer of Guest Keen Baldwins Iron & Steel Company, Limited, covering all their works, as from December 1.

AFTER 35 years' service with Carron Company, Mr. Andrew Patrick, manager of Mungal Foundry, has retired. He has been presented with a sitting-room suite, from the employees and his managerial colleagues.

MR. C. H. SPARKS, chief engineer of Babcock & Wilcox, Limited, and Mr. C. K. F. Hague, general sales manager, have been appointed to the board of the company, to fill the vacancies created by the death of Sir Robert B. Dixon and Mr. C. S. Davy.

MR. ALLEN JOHN GRANT, managing director of Thos. Firth & John Brown, Limited, has rejoined the board of John Brown & Company, Limited. Mr. S. W. Rawson has joined the board of Thos. Firth & John Brown, Limited, and will act as sales director in succession to the late Mr. Edward Dixon. Mr. Mark Firth, who has been with the firm for the past 20 years and was made a director in 1935, has been appointed to assist the managing director as director of miscellaneous services, and will continue to co-ordinate the company's wartime emergency programme, on which he has been engaged since its inception. The Hon. Charles M. McLaren, a director of John Brown & Company, Limited, has also been appointed to the board of Thos. Firth & John Brown, Limited.

Will

TURNBULL, F. H., of Penarth, late chairman and managing director of Edward Curran & Company, Limited, enamelled steel hollow-ware manufacturers, and a director of Cardiff Foundry & Engineering Company, Limited ... £25,210

Obituary

MR. LEONARD BURBIDGE, London manager of Blackstone & Company, Limited, Stamford, died suddenly on December 1. Before joining Blackstone's, Mr. Burbidge spent several years in the U.S.A. as manager of the technical sales staff of Peet & Powers, Inc., of New York.

MR. CHARLES RUSSELL LANG, senior director of G. & J. Weir, Limited, Holm Foundry, Cathcart, died last week. Mr. Lang, who has been a distinguished figure in the engineering industry of the West of Scotland for more than 50 years, was a member of the famous machine-tool family of John Lang & Sons, Johnstone, near Glasgow, with which firm he served his engineering apprenticeship. Mr. Lang was a Whitworth Scholar. He joined the firm of G. & J. Weir, Limited, in 1887 as works manager, subsequently becoming a director and joint managing director. Mr. Lang took a keen interest in the technical side of his profession, and contributed a number of Papers to the Institution of Engineers and Shipbuilders in Scotland. He was awarded a C.B.E. in 1918.

Reports and Dividends

W. & T. Avery, Limited—Interim dividend of 5 per cent. on the ordinary shares.

Leeds Piston Ring & Engineering Company, Limited—Interim dividend of 2½ per cent.

John I. Thornycroft & Company, Limited—Dividend of 10 per cent. on the ordinary shares.

Broom & Wade, Limited—Net profit for the year to September 30 last, £87,813; final dividend on the ordinary shares of 15 per cent., making 22½ per cent. for the year.

Allied Ironfounders, Limited—The directors have decided to defer consideration of a dividend on the ordinary share capital until accounts for the complete year are available.

John Williams & Sons (Cardiff), Limited—Profit for the year ended September 30, after providing for taxation, pension reserve, special reserve for depreciation, etc., £15,590; brought in, £9,591; final dividend on the ordinary shares of 7½ per cent., making 12½ per cent., free of tax; to general reserve, £6,000; carried forward, after preference dividend, £8,181.

J. Brockhouse & Company, Limited—Credit balance at September 30, after charging depreciation, etc., £429,758; dividend on the preference stock, £900; interim dividend on the ordinary stock of 7½ per cent., £25,781; to taxation reserve, £225,000; final dividend on the ordinary stock of 12½ per cent., making 20 per cent., £50,312; carried forward, £127,764.

William Asquith, Limited—Profit for the period, August 18, 1939, to August 15, 1940, after charging depreciation, £100,155; brought in, £30,632; taxation, £80,000; dividend of 8 per cent. on the cumulative participating preference shares, £7,965; interest on the non-cumulative redeemable funding certificates, £1,210; dividend of 5 per cent. on the ordinary shares, £2,333; to general reserve, £10,000; carried forward, £29,279.

Dorman, Long & Company, Limited—Full report shows:—Profit on trading, etc., £1,395,029; balance after taxation, £956,179; interest on 4 per cent. perpetual debenture stock, £16,000; interest on 4 per cent. redeemable prior lien stock, £23,932; sinking fund, 4 per cent. prior lien stock, £6,000; interest on 5 per cent. redeemable debenture stock, £157,295; sinking fund, 5 per cent. debenture stock, £37,077; depreciation, £275,000; dividend on 6½ per cent. non-cumulative first preference shares, £185,768; pension fund, £15,000; brought in, £157,501; dividend on 8 per cent. non-cumulative second preference shares, £53,035; dividend of 8 per cent. on preferred ordinary shares, £41,055; further dividend of 7 per cent. on preferred ordinary shares, £35,923; dividend of 7 per cent. on ordinary shares, £110,680; carried forward, £156,915.

Application for Trade Mark

The following application to register a trade mark has been taken from the "Trade Marks Journal":—

"POWDIRON"—Parts of machines. BOUND BROOK OIL-LESS BEARING COMPANY, c/o Marks & Clerk, 57-58, Lincoln's Inn Fields, London, W.C.2.

Contracts Open

Cairo, December 21—Iron and other metals, etc., for the Director-General, Tanzim Department, Ministry of Public Works. The Inspecting Engineer to the Egyptian Government, 41, Tothill Street, London, S.W.1.

Colchester, December 16—Construction of a pipeline comprising 2,203 yds. of 12 in. dia., 358 yds. 10 in. dia. and 1,568 yds. 9 in. dia. pipe, for the Town Council. Mr. H. Collins, borough engineer, Water Supply Department, 3, Bank Passage, Colchester. (Fee £2 2s., returnable.)

Dublin, December 17—Supply and erection of centralised steam plant, for the Joint Committee of Grangegorman Mental Hospital. Mr. F. C. Ward, quantity surveyor, 133, Griffith Avenue, Dublin. (Fee £10 10s., returnable.)

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

B. Dixon-Bate, Limited, Bridge Works, Tarvin Road, Chester—Capital, £20,000. Engineers. Directors: B. Dixon Bate, J. Pruett, C. P. Witter and M. H. Williams.

Ottowell & Company, Limited, 1, Warwick Street, London, W.1—Capital, £10,000. Chemical manufacturers, dealers in machinery, etc. Directors: T. T. Ottowell and H. V. T. Murray.

Castings Patent Dispute

An action to recover damages for an alleged infringement of patent brought by International de Lavaud Manufacturing Corporation, Limited, of Canada; Cochranes (Middlesbrough) Foundry, Limited, of Middlesbrough; and the Stanton Ironworks Company, Limited, of Stanton-by-Dale, Derbyshire, against the Clay Cross Company, Limited, of Clay Cross, near Chesterfield, has been before Mr. Justice Bennett in the Chancery Division in the last two weeks.

Mr. Kenneth Swan, K.C., for the plaintiffs, stated that an injunction had also been claimed, but since the proceedings were started in 1938 the patent had lapsed and it was now a question of damages only. The patent concerned the production of unhardened metallic castings in metal moulds.

The hearing continues.

Calcium in Metallurgy

Calcium continues to find new uses in the metallurgical industry, points out C. L. MANTELL in "Metal Progress," including the following:—(*a*) As a deoxidiser and alloying agent for non-ferrous metals such as copper and lead; (*b*) in the preparation of high-temperature, high-resistance nickel-chromium and nickel-chromium-iron alloys; (*c*) in the form of its hydrides as a reducing agent for the production of rare metals such as titanium, vanadium, uranium and zirconium.

Forthcoming Events

DECEMBER 14.

Manchester Association of Engineers:—Quarterly meeting. "Some Experiences in Organising the Design and Manufacture of Small Engineering Apparatus." Paper by G. A. Cheetham, at Manchester, at 2.30 p.m.

DECEMBER 16.

Iron and Steel Institute:—Joint meeting of members resident in Middlesbrough with the Cleveland Institution of Engineers. "Manufacture of Steel by the Perrin Process." Paper by B. Yaneske, at Middlesbrough, at 6.30 p.m.

Institute of British Foundrymen

DECEMBER 14.

East Midlands Branch:—"Developments in Foundry Refractories." Paper by E. J. Crawley, at Derby.

Scottish Branch:—"Observations on Contraction in Cast Iron." Paper by E. Longden, at Glasgow, at 3 p.m.

West Riding of Yorkshire Branch:—Discussion on Report of Melting Furnaces Sub-Committee of the Institute's Technical Committee, "Melting Furnaces for Grey Cast Iron," opened by F. K. Neath, at Bradford, at 6.30 p.m.

DECEMBER 20.

Falkirk Section:—Discussion on Report of Melting Furnaces Sub-Committee of the Institute's Technical Committee, at Falkirk, at 7 p.m.

A Refractories Industry within one organisation

The spectacular achievements of industries which use refractories tend to overshadow the remarkable development of refractory materials during recent years. Higher temperatures and increasingly severe operating conditions have long since deposed "rule-of-thumb" methods of manufacture. Research—applied by the refractories industry, by manufacturers (such as General Refractories), and by users—has developed a range of refractories which are, at least, abreast of to-day's metallurgical processes and plant design. Unrivalled supplies of raw materials—the employment in its many works of modern plant and equipment—the services of leading technicians, operating in works bearing names familiar to all users—and supported by a wealth of practical experience—enable General Refractories to operate a complete refractories service inside one organisation. And, influencing all activities, controlling production and future development, is "G.R." Research. In modernly equipped laboratories a team of qualified chemists and engineers build into each "G.R." product that consistently uniform quality which is the basis of low operating costs and long dependable service.

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BASIC BRICKS: *Spinella, Saxpyre, Supermag, Diazite, Dolomax.*
ACID-PROOF REFRACTORIES: *Obsidianite, Losol.*

INSULATION: *Amberlite* Bricks, Cement and Concrete.
SILICA BRICKS: *Lowood, Meltham, Allen, Quartex.*
CEMENTS: *Sintex, Durax, Pyrolyte.* PLASTICS: *Durax, Rotaline, Plastic K-N., Glendoline, Ground Ganister.*
SILLIMANITE: Tank Blocks, Bricks and Cements.
SANDS: Moulding, Brick Facing, Silica, Glass.

Raw Material Markets

Makers of heavy castings, being mainly engaged on Government contracts, are receiving priority attention in the matter of pig-iron distribution, and adequate deliveries are being made to these concerns. Light-castings manufacturers, on the other hand, are not getting as much war work as they would desire, and many are still unable to maintain full-time operations, although there has been steady improvement in this direction of late. High-phosphorus iron, produced from home ores, is largely utilised by these works and ample supplies are available. Very gratifying outputs are being recorded by the steel industry, and it is no reflection upon makers that substantial imports of foreign steel are required to meet the heavy demands of Government departments. Cast-iron scrap, now slightly higher in price, is being used freely by consumers of foundry pig-iron, but the supply is fully sufficient, as is also true of most other descriptions of scrap iron and steel.

Pig-Iron

MIDDLESBROUGH — Pig-iron consumption among local foundrymen continues to be at a high level. Heavy engineering concerns, of course, account for the bulk of deliveries arriving here, but increased demands are also emanating from light-castings makers, many of whom have become much busier during the past few weeks. Midlands suppliers of foundry iron are able to cope with all requirements, but it cannot be said that they have any great amount of iron to spare. A fair quantity of cast-iron scrap is being used by foundries, thus relieving the pressure on foundry numbers. The call for hematite has been increasing for some time past, and there is every indication that still heavier demands will be made on this type of iron in the future. If this proves to be the case, larger tonnages will be needed from abroad, as the home production is already fully taxed, although it is hoped that outputs will be materially expanded to meet eventualities. Quite a considerable tonnage of hematite has been brought from overseas, but the need for maintaining imports at as low an ebb as possible is obvious.

LANCASHIRE—Despite a quietening of the demand from some users of pig-iron, there remains a heavy call, especially from foundries catering for speciality engineering concerns, and no relaxation can be expected for a long time yet, as most of this work is on Government account. Many jobbing foundries are not receiving sufficient business fully to replace contracts being completed, while the position of the light-castings makers is slow to improve, although more work appears to be now available in this section. Midlands producers, on the whole, are despatching adequate supplies of foundry iron to Lancashire buyers, and any delay is usually attributable to transport.

MIDLANDS—High-phosphorus iron is readily available to consumers, the bulk being taken up by makers of light castings, whose position has improved compared with the very unfavourable conditions which persisted a short time ago. The trade is still not fully employed, and is unlikely to be so for some time, but recent weeks have been marked by a greater call on the products of this section. Some relaxation has been made by the Control authorities with regard to deliveries of high-phosphorus iron, and many consumers have been permitted to build up small reserve stocks, which may prove extremely useful later. This type of iron is also being used on a moderate scale by heavy engineering establishments, but these works, too, are able to acquire all they need. While special grades of hematite are not coming to hand so freely as might be the case, ordinary brands are being delivered satisfactorily, while low-phosphorus iron, also, is available without difficulty. These irons are being taken up in substantial tonnages by heavy engineers, who are mostly operating to capacity on work of national importance. Machine-tool works and jobbing foundries are actively engaged, and are likely to remain so.

SCOTLAND—Consumption of foundry iron among Falkirk and district light-castings producers is steadily rising, and is now higher that it has been for many months past, thus indicating the improvement which has matured of late. Even so, works are by no means fully employed, and more business is being sought by most foundrymen. Government orders almost solely ensure full-scale operations among heavy engineers, who have little difficulty in securing their total requirements of pig-iron. At the same time, most consumers are working on a hand-to-mouth basis and would welcome the opportunity to lay down stocks of iron.

Coke

Although no official intimation has yet been made, it is expected that deliveries of foundry coke on and after December 1 last will be charged at 6d. per ton above the existing quotation of 58s. for Durham best coke, delivered Birmingham and Black Country stations, as some allowance will have to be made, it is presumed, for the increase of 6 per cent. in railway freight rates which came into force on that date. The supply position may be regarded as being quite satisfactory; the larger users have, in most instances, considerable stocks on hand and are now purchasing their day-to-day requirements. Inland consumption of foundry coke has expanded during recent months and has thus compensated ovens to some extent for the loss of many former foreign outlets, although coke makers still feel the drying up of export business.

Steel

Steelmakers continue to be busily employed in dealing with licensed deliveries covering the final quarter of this year, and shortly will be faced with demands on account of the first three months of the new year. Works' outputs are at record levels, but are, nevertheless, insufficient fully to deal with wartime requirements, which appear to be insatiable. Consequently, it is necessary to arrange for considerable importations, but the Control are limiting these to the lowest convenient amount. The onus of allocating supplies rests entirely on the Iron and Steel Control, producers merely complying with their delivery instructions. Despite certain drawbacks, this system is operating satisfactorily, and is ensuring that supplies are directed into the most urgent channels.

Scrap

The iron and steel scrap situation has progressed beyond all expectations, and supplies are now available to meet all requirements, with the additional advantage of facilities being granted for stocking. Some consuming works are, in fact, in possession of as much material as they can conveniently handle and are having to hold back further deliveries for the time being. In most districts new business is now on the quiet side, but this fact is not being allowed to preclude the collection of additional material. Maximum prices of scrap iron and steel have been increased as from Monday last to meet the higher rail charges. The increases are small, and will not affect foundry costs to any great extent. In the case of cast-iron scrap the advance is limited to 6d. per ton. Part of the advance is to contribute towards merchants' additional costs, while there has also been an adjustment for certain special grades of scrap iron and steel. Merchants are now allowed to charge 3¼ per cent. above the maximum prices, against 2½ per cent. previously. The new prices for representative grades of scrap will be found on page 16.

Metals

Copper supplies for the war machine are coming through satisfactorily, but allocations for less important uses are restricted. Domestic sales in the United States remain at a high level, although there has been some falling away since the inflated business of September and October. Primary producers are quoting 12 cents per lb. for electro, delivered Valley, but Customs smelters are asking 12.25 cents.

The Rhokana Corporation had been able to meet to the full the varying requirements of copper of the Ministry of Supply at reasonable prices paid in sterling since the outbreak of war, said Mr. Francis L. Gibbs (deputy chairman) at the annual meeting last week. The Corporation had also been able to assist the country's war effort by the provision of large sums of money to the Treasury. It was not possible to make public the extent of their mining activities, but during the year operations had continued normally and satisfactorily except for two interruptions. For the purpose of estimating the Corporation's liability to Excess Profits Tax, the computation of their pre-war standard had to include the results of a period when they had not yet completed their main programme of development and equipment. They had submitted to the authorities all the relevant facts which in their opinion rendered such a method of computation inequitable, but the Government had been unable to grant them any relief in that respect. The result was that on their present estimates of tax liability, despite an increased operating profit of over £730,000, the reserve which the directors found it necessary to make for taxation left less profit available for distribution than in the previous year. The question of the incidence of E.P.T. on mining concerns was also raised by Mr. J. Ivan Spens, chairman of Amalgamated Tin Mines of Nigeria, at the annual meeting of that concern. He said that the Excess Profits Tax, as the Act was now framed, placed a burden on tin-producing companies which was considerably heavier than had to be borne by other industries. No amortisation of property or ore reserves was allowed for tax purposes, with the result that, after a certain figure of profits had been reached, tin companies were in a position in which they depleted their ore reserves (and with the quota at its present level the rate of depletion was very heavy) and got not only no additional profit, but no compensation for the consequent reduction of the life of the mine. The tax had the effect, therefore, of a capital levy.

It is understood that the deferred meeting of the International Tin Committee will be held on December 16 in London. The meeting had been postponed earlier largely in order to permit the attendance of Mr. van den Broek, the Committee's delegate who negotiated the sale of reserve tin to the American Government. It is expected that the meeting will be mainly concerned with Mr. van den Broek's account of the American deal, while the U.S. smelting scheme will also figure on the agenda.

The tin market in the United Kingdom is still rather lifeless, business involving comparatively small tonnages and prices remaining fairly steady.

London Metal Exchange tin prices this week has been as follow:—

Cash—Thursday, £256 15s. to £257; Friday, £257 to £257 5s.; Monday, £256 15s. to £257 5s.; Tuesday, £256 15s. to £257 5s.; Wednesday, £256 10s. to £256 15s.

Three Months—Thursday, £259 15s. to £260 5s.; Friday, £259 15s. to £260; Monday, £259 15s. to £260; Tuesday, £259 15s. to £260; Wednesday, £259 15s. to £260.

MAGNETIC SEPARATORS
"RAPID-BIAFLUX" Patent
PULLEY & DRUMS
The Popular
"OVERBAND"
FOR FOUNDRY SANDS
LISTED IN 5 SIZES
LIFTING MAGNETS
FOR PIG IRON & SCRAP
CLUTCHES & CHUCKS
THE RAPID MAGNETTING MACHINE Co., Ltd.,
Magnet Works, Lombard St., Birmingham, 12
'Phone: Victoria 1137-8 'Grams: 'Borings, Birmingham.'

Wind from the right quarter . . .

With a favourable wind the clipper races across the ocean, her tall tapering masts and gleaming spread of snowy canvas providing a picture of loveliness and grace . . .

Industry also demands a satisfactory source of air supply, and instinctively turns to the manufacturers of Fans who have the necessary experience and knowledge which ensure the quality and efficiency of their products.

In Foundries, where comparatively high pressures are required for the supply of air blast to forges and cupolas, "Sirocco" High-Pressure Fans offer dependable service, and numerous installations testify to their excellence and suitability. A wide range of sizes and designs ensures correct fulfilment of individual requirements.

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TITAN WORKS, BIRMINGHAM 12

RAW MATERIALS—PRICE LIST

Wednesday, December 11, 1940

COPPER*

	£	s.	d.
Electrolytic	62	0	0
High-grade fire-refined ..	61	10	0
Fire-refined of not less than 99.7 per cent.	61	0	0
Do., do., 99.2 per cent. ..	60	10	0
Black hot-rolled wire rods..	65	10	0

TIN

	£	s.	d.
Standard cash	256	10	0
Three months	259	15	0
Settlement..	256	10	0
Official average Cash, Nov.	258	7	6
Do. Three Months, Nov.	260	5	1½
Do. Settlement, Nov. ..	258	6	5½

SPELTER*

	£	s.	d.
G.O.B. (foreign) (duty paid)	25	15	0
Do. (domestic)	26	10	0
"Prime Western" ..	26	10	0
Refined and electrolytic ..	27	5	0
Not less than 99.99 per cent.	28	15	0

LEAD*

	£	s.	d.
Good soft pig lead (foreign) (duty paid)	25	0	0
Do., do., (Empire and domestic)	25	0	0
English	26	10	0
Sheets, home	34	10	0
Do. export, f.o.b. ..	30	0	0
Pipes, home	34	0	0
Do. export, f.o.b. ..	30	10	0
Tea lead (nom.)		—	

ALUMINIUM

Ingots	£110
Wire, 10g.	nom.
Sheets	nom.
Circles, 20/24g.	nom.

ZINC SHEETS, etc.

	£	s.	d.
Sheets, 10g. and thicker, ex works..	39	2	6
Rolled zinc (boiler plates), ex works..	37	2	6
Zinc oxide (Red Seal), d/d buyers' premises ..	28	7	6

ANTIMONY

English, 90%, delivered ..	90 0 0
Foreign Regulus, duty paid ..	90 0 0 to 93 0 0
Chinese, prompt shipment, c.i.f. ..	78 0 0 to 82 0 0

QUICKSILVER

Quicksilver, ex-w'hse London	48 0 0 to 51 0 0

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	3s. 0d.
Finished bars, 18% tungsten	3s. 10d.
Finished bars, 22% tungsten	4s. 4d.

Per lb. d/d buyers' works.

NICKEL SILVER, etc.

	Per lb.
Ingots for raising ..	9d. to 1/3
Rolled—	
To 9 in. wide ..	1/3 to 1/9
To 12 in. wide ..	1/3½ to 1/9½
To 15 in. wide ..	1/3½ to 1/9½
To 18 in. wide ..	1/4 to 1/10
To 21 in. wide ..	1/4½ to 1/10½
To 25 in. wide ..	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/- to 1/8½
Wire round—	
to 10g.	1/6½ to 2/1½

with extras according to gauge.

Special 5ths quality turning rods in straight lengths, 1/5½ upwards.

* Maximum prices per long ton delivered to buyers' premises.

FERRO-ALLOYS AND STEEL-MAKING METALS

(all prices nominal.)

	£	s.	d.
Ferro-silicon (5-ton lots)—			
25%	18	10	0
45%	23	10	0
75%	36	10	0
Ferro-vanadium—			
35/50%	15/6 lb. Va.		
Ferro-molybdenum—			
70/75% carbon-free ..	6/- lb. Mo.		
Ferro-titanium—			
20/25% carbon-free ..	1/9 lb.		
Ferro-tungsten—			
80/85%	5/1 lb.		
Tungsten metal powder—			
98/99%	5/2½ lb.		
Ferro-chrome—			
2/4% car.	—		
4/6% car.	47	0	0
6/8% car.	47	0	0
8/10% car.	—		
Ferro-chrome—			
Max. 2% car.	—		
Max. 1% car.	—		
Max. 0.5% car.. ..	—		
70% carbon-free ..	—		
Nickel—99.5/100%	£190 to £195		
"F" nickel shot ..	175	0	0
Ferro-cobalt, 98/99% ..	8/9 lb.		
Metallic chromium—			
96/98%	3/9 lb.		
Ferro-manganese—			
76/80% loose	18	10	0
76/80% packed	20	0	0
Metallic manganese—			
94/96% carbon-free ..	1/9 lb.		

Per ton unless otherwise stated, basis 2-ton lots, d/d Sheffield works.

SCRAP*

	£	s.	d.	£	s.	d.
SOUTH WALES—						
Short heavy steel, not ex. 24-in. lengths ..	4	2	0	to 4	4	6
Heavy machinery cast iron			4	7	0	
Ordinary heavy cast iron			4	2	0	
Cast-iron railway chairs			4	7	0	
Medium cast iron ..			3	18	3	
Light cast iron			3	13	6	
MIDDLESBROUGH—						
Short heavy steel	3	19	9	to 4	2	3
Heavy machinery cast iron			4	11	9	
Ordinary heavy cast iron			4	9	3	
Cast-iron railway chairs			4	9	3	
Medium cast iron ..			3	19	6	
Light cast iron			3	14	6	
BIRMINGHAM DISTRICT—						
Short heavy steel	3	14	9	to 3	17	3
Heavy machinery cast iron			4	12	3	
Ordinary heavy cast iron			4	7	6	
Cast-iron railway chairs			4	7	6	
Medium cast iron ..			4	0	3	
Light cast iron			3	15	3	
SCOTLAND—						
Short heavy steel	3	19	6	to 4	2	0
Heavy machinery cast iron			4	14	3	
Ordinary heavy cast iron			4	9	3	
Cast-iron railway chairs			4	14	3	
Medium cast iron ..			3	17	3	
Light cast iron			3	12	3	

* Delivered free to consumers' works in England and Wales. For deliveries of cast-iron scrap free to consumers' works in Scotland, the above prices less 3s. per ton, but plus actual cost of transport or 6s. per ton, whichever is the less. All prices: Plus 3¾ per cent. dealers' remuneration: 50 tons and upwards over three months 2s. 6d. extra.

PIG-IRON*

	£	s.	d.
N.E. COAST (d/d Tees-side area)—			
Foundry No. 1	131/-		
„ No. 3	128/-		
„ No. 4	127/-		
Forge No. 4	127/-		
Hematite No. 1	138/6		
Hematite M/Nos.	138/-		
N.W. COAST—			
Hem. M/Nos. d/d Glasgow	138/6		
„ d/d Birmingham ..	150/-		
MIDLANDS (d/d Birmingham dist.)—			
Staffs No. 4 forge	129/-		
„ No. 3 fdry.	130/-		
Northants forge	126/6		
„ fdry. No. 3 ..	127/6		
„ fdry. No. 1 ..	130/6		
Derbyshire forge	129/-		
„ fdry. No. 3 ..	130/-		
„ fdry. No. 1 ..	133/-		
Phosphorus 0.5% to 0.75%	137/6		
Phosphorus 0.1% to 0.5%	140/6		
SCOTLAND—			
Foundry No. 1, Grangemouth	127/3		
„ No. 3, Grangemouth	124/9		
Cleveland No. 3, Glasgow	131/-		
„ „ Falkirk ..	128/-		
Scottish hem. M/Nos. d/d..	138/6		
SHEFFIELD (d/d district)—			
Derby forge	126/6		
„ fdry. No. 3 ..	127/6		
Lincs forge	126/6		
„ fdry. No. 3 ..	127/6		
W.C. hematite	144/-		
LANCASHIRE (d/d eq. Man.)—			
Derby fdry. No. 3 ..	133/-		
Staffs fdry. No. 3	133/-		
Northants fdry. No. 3 ..	131/6		
Cleveland fdry. No. 3 ..	133/-		
Cylinder and Refined Irons			
North Zone..	174/-		
South Zone..	176/6		
Refined Malleable			
Birmingham and S. Staffs	171/6		
Cold Blast			
South Staffs	220/6		

* Prices of hematite and basic pig-iron, and of foundry and forge iron with a phosphoric content of not less than 0.75 per cent., are subject to a rebate of 5s. per ton under certain conditions.

SEMI-FINISHED STEEL

Re-rolling Billets, Blooms and Slabs.

	£	s.	d.
BASIC:			
Soft, u.t., 100-ton lots ..	12	5	0
Tested, up to 0.25% C. ..	12	10	0
Tested, 0.25 to 0.33% C.	12	12	6
Tested, 0.33 to 0.41% C...	12	15	0
Hard (0.42 to 0.60% C.)..	13	17	6
„ (0.61 to 0.85% C.)..	14	7	6
„ (0.86 to 0.99% C.)..	14	17	6
„ (1% C. and up) ..	15	7	6
Silico-manganese	16	5	0
Free-cutting	14	10	0
SIEMENS MARTIN ACID			
Up to 0.25% C.	15	15	0
Case-hardening	16	12	6
Silico-manganese	16	5	0

Billets, Blooms and Slabs for Forging and Stamping.

Basic soft, up to 0.25% C. ..	13	17	6
Basic hard, 0.41 to 0.60% C.	14	10	0
Acid, up to 0.25% C. ..	16	5	0

Other Semi-products, etc.

Tin bars	12	2	6
Sheet bars	12	2	6
*Wire rods, soft basic ..	17	7	6
„ hard basic ..	21	2	6
„ free-cutting ..	20	2	6
„ acid	24	13	

* Subject to rebate

FINISHED STEEL

Usual district deliveries.

[A rebate of 15/- per ton for steel bars, sections, plates, joists and hoops is obtainable in the home trade under certain conditions.]

	£	s.	d.
Plates, ship (N.E. Coast) ..	16	3	0
Boiler plts. (N.E. Coast) ..	17	0	6
Chequer plts. (N.E. Coast)	17	13	0
Angles, over 4 un. ins. ..	15	8	0
Tees, over 4 un. ins. ..	16	8	0
Joists, 3 in. × 3 in. and up	15	8	0
Rounds and squares, 3 in. to 5½ in.	16	8	0
Rounds under 3 in. to ⅜ in. (untested)	17	12	0
Flats—over 5 in. wide ..	15	13	0
„ 5 in. wide and under ..	17	12	0
Rails, heavy, f.o.t. ..	14	10	6
Hoops	18	7	0
Black sheets, 24 g. (4 t. lots)	22	15	0
Galv. cor. shts. („)	26	2	6
Galv. flat shts. („)	26	12	6
Galv. fencing wire, 8g. plain	26	17	6

FINISHED IRON

	£	s.	d.
CROWN IRON:			
England and Wales ..	15	12	6
Scotland	15	12	6
Ireland, f.o.q.	16	5	0
No. 3 BARS:			
England and Wales ..	12	10	0
Scotland	13	12	6
Ireland, f.o.q.	13	2	6
No. 4 BARS:			
England and Wales ..	13	0	0
Scotland	13	17	6
Ireland, f.o.q.	13	12	6
STRIP:			
England and Wales ..	17	0	0
STAFFS MARKED BARS, f.o.t...		—	

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated, November 14, 1940.

	Dols.
No. 2 foundry, Phila.	24.84
No. 2 foundry, Valley	23.00
No. 2 foundry, Birm.	19.38
Basic, Valley	22.50
Malleable, Valley..	23.00
Grey forge, Valley	22.50
Ferro-mang., seaboard	120.00
O.-h. rails, h'y, at mill	40.00
Billets	34.00
Sheet bars	34.00
	Cents
Iron bars, Chicago	2.25
Steel bars	2.15
Tank plates	2.10
Beams, etc.	2.10
Wire rods	2.00
Skelp, grooved steel	1.90
Steel strip	2.10
Steel sheets	2.10
Sheets, galv., 24 g.	3.50
Wire nails	2.55
Plain wire	2.60
Tinplates, 100-lb. box	$5.00

COKE (at ovens)

(nominal)

Welsh foundry	46/6 to 48/-
„ furnace	35/6 to 37/-
Durham foundry	42/-
„ furnace	35/6
Scottish foundry	45/- to 50/-
„ furnace	33/6 to 35/6

TINPLATES

(f.o.b Bristol Channel ports)

I.C. cokes	20 × 14 per box	30/9 to 32/-
„	28 × 20 „	61/6 to 64/-
„	20 × 10 „	44/3 to 44/9
„	18¼ × 14 „	32/- to 32/6
C.W.	20 × 14 „	27/9 to 28/9
„	28 × 20 „	55/6 to 57/6
„	20 × 10 „	42/3 to 42/9
„	18¼ × 14 „	30/- to 30/6

NON-FERROUS SCRAP

(Official Maximum Prices, per ton ex Works.)

	£	s.	d.
Bright untinned copper wire, in crucible form or in hanks	57	10	0
No. 1 copper wire	57	0	0
No. 2 copper wire	55	10	0
Copper firebox plates, cut up	57	10	0
Clear untinned copper, cut up	56	10	0
Braziery copper	53	10	0
Q.F. process and shell-case brass, 70/30 quality, free from primers	49	0	0
Clean fired 303 S.A. cartridge cases	47	0	0
70/30 turnings, clean and baled	43	0	0
Brass swarf, clean, free from iron and commercially dry	34	10	0
New brass rod ends, 60/40 quality	38	10	0
Hot stampings and fuse metal, 60/40 quality	38	10	0
Admiralty gunmetal, 88-10-2, containing not more than ¼ per cent. lead or 3 per cent. zinc, or less than 9½ per cent. tin	72	0	0

NEW BRASS TUBES, etc.

	Per lb.
Solid drawn tubes	13½d.
Brazed tubes	15½d.
Rods, drawn	11½d.
Rods, extd. or rlld.	8½d.
Sheets to 10 w.g.	10½d.
Wire	10½d.
Rolled metal	9½d.
Yellow metal rods	8½d.

COPPER TUBES, etc.

Solid drawn tubes	14½d.
Brazed tubes	14½d.
Wire	9½d.

PHOSPHOR BRONZE

	Per lb. basis
Strip	13½d.
Sheet to 10 w.g.	13½d.
Wire	15½d.
Rods	15½d.
Tubes	20½d.
Castings	17d.

Delivery 3 cwt. free.
10% phos. cop. £35 above B.S.
15% phos. cop. £40 above B.S.
Phosphor tin (5%) £40 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

AVERAGE MONTHLY PRICES OF UNMARKED BARS (SOUTH STAFFS)

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1905	6 5 0	6 5 0	6 0 0	5 17 6	5 15 0	5 15 0	5 15 0	5 15 0	6 0 0	6 5 0	6 15 0	6 15 0	6 1 10
1906	7 0 0	7 5 0	7 5 0	7 5 0	6 17 6	6 15 0	6 12 6	6 10 0	6 10 0	6 12 6	6 16 3	7 3 9	6 17 3
1907	7 3 9	7 5 0	7 5 0	7 5 0	7 5 0	7 7 6	7 5 0	7 7 6	7 7 6	7 7 6	7 7 6	7 5 0	7 5 11
1908	7 2 6	7 0 0	7 0 0	7 0 0	6 15 0	6 7 6	6 5 0	6 2 6	6 2 6	6 2 6	6 2 6	6 0 0	6 10 9½
1909	6 0 0	6 0 0	6 0 0	5 17 6	6 0 0	6 0 0	5 17 6	6 0 0	6 0 0	6 2 6	6 2 6	5 17 6	5 19 9
1910	6 2 6	6 3 4½	6 7 6	6 7 6	6 7 6	6 7 6	6 6 6	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 7
1911	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 10 0	6 12 6	6 16 6	6 7 9
1912	6 18 9	7 1 10	7 2 6	7 8 9	7 18 0	8 0 7	8 2 6	8 3 6	8 5 0	8 6 3	8 7 6	8 8 9	7 17 9
1913	8 11 6	8 10 7½	8 10 0	8 8 1½	8 2 0	8 0 0	7 17 6	7 11 6	7 8 9	7 5 6	6 18 1½	6 17 6	7 16 9
1914	6 17 6	6 15 7½	6 12 6	6 10 0	6 10 0	6 10 0	6 10 0	7 11 10½	8 0 0	7 12 6	7 5 7½	7 6 3	7 1 0
1915	7 11 6	8 5 11	8 8 9	9 6 0	10 3 2	10 19 2	11 12 6	11 13 1½	11 13 9	11 14 3	12 1 10½	13 0 9	10 6 0½
1916	13 7 6	13 10 8	13 12 9½	13 15 0	13 15 0	13 16 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 3 9
1917	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0½
1918	13 15 0	13 17 3	13 17 6	13 17 6	13 17 6	13 17 6	13 17 6	14 15 0	14 15 0	14 15 0	14 15 0	14 15 0	14 4 9
1919	15 10 0	16 5 0	17 15 0	17 15 0	20 15 0	21 0 0	21 0 0	22 0 0	22 0 0	22 0 0	22 7 6	22 12 6	20 1 8
1920	24 7 6	24 10 0	25 10 0	27 10 0	29 5 0	31 0 0	31 10 0	31 10 0	31 10 0	31 10 0	31 10 0	29 7 6	29 1 8
1921	26 17 3	25 0 0	23 0 0	21 0 0	19 0 0	18 5 0	16 0 0	16 0 0	15 14 0	14 0 0	13 6 8	13 0 0	19 4 5½
1922	13 0 0	12 3 9	11 14 0	11 11 10½	11 5 0	11 3 6	11 2 6	11 5 0	10 17 2½	10 16 3	10 13 0	10 12 6	11 7 0½
1923	10 16 10½	11 3 1½	12 2 6	12 8 9	12 11 6	12 1 3	11 15 11½	11 15 0	11 15 0	11 15 0	12 13 6	12 8 3	11 18 10½
1924	12 9 6	12 10 0	12 10 0	12 15 7½	12 17 6	12 17 6	12 17 6	12 17 6	12 17 6	12 14 0	12 12 6	12 12 6	12 14 3½
1925	12 12 6	12 12 6	12 12 6	12 12 6	12 12 6	12 7 6	12 7 6	12 7 6	12 4 6	11 18 6	11 13 9	11 13 0	12 6 2
1926	11 7 9½	11 5 0	11 5 0	11 5 0	11 3 9	11 3 9	11 5 0	12 0 0	13 0 0	*	15 7 6	12 19 0	12 0 2
1927	12 6 3	12 2 6	11 14 0	11 0 0	10 18 9	10 13 6	10 12 6	10 5 0	9 16 0	9 15 0	9 13 9	9 12 9	10 14 2
1928	9 12 6	9 12 6	9 11 0	9 10 0	9 8 4	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 3 6	9 1 3	9 7 0
1929	9 0 0	9 2 6	9 5 7½	9 9 4½	9 10 0	9 17 6	10 2 6	10 2 6	10 2 6	10 0 6	10 3 9	10 5 7	9 15 2½
1930	10 7 6	10 7 6	10 7 6	10 6 10½	10 6 3	10 5 0	16 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 4 7½
1931	10 2 6	10 0 0	10 0 0	10 0 0	9 18 1½	9 17 6	9 17 6	9 17 6	9 17 6	9 17 6	9 17 6	9 16 10½	9 18 0½
1932	9 15 0	9 15 0	9 15 0	9 15 0	9 13 9	9 11 3	9 10 0	9 10 0	9 10 0	9 6 3	9 5 0	9 5 0	9 10 11½
1933	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0
1934	9 5 0	9 8 1½	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 11 6
1935	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6
1936	9 12 6	9 15 0	10 2 6	10 2 6	10 2 6	10 2 6	10 6 3	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 4 5½
1937	10 10 0	10 10 0	11 17 6	11 17 6	11 17 6	11 17 6	12 4 6	13 5 0	13 5 0	13 5 0	13 5 0	13 5 0	12 4 11½
1938	13 5 0	13 5 0	13 5 0	13 5 0	13 5 0	13 5 0	13 5 0	13 5 0	15 3 0	13 5 0	13 5 0	13 5 0	13 5 0
1939	12 5 0	12 5 0	12 5 0	12 5 0	12 5 0	12 5 0	12 5 0	12 5 0	12 5 0	12 5 0	12 5 0	12 15 0	12 6 8
1940	12 15 0	12 17 6	12 17 6	13 16 3	14 2 6	14 2 6	15 2 6	15 2 6	15 2 6	15 2 6	15 12 6	—	—

* No quotation available owing to strike.

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